Radiological Health Data and Reports

VOLUME 11, NUMBER 2

FEBRUARY 1970

(Pages 47–106)

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service ● Environmental Health Service

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	$0.386\ nCi/m^2\ (mCi/km^2)$
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	$2.59\ mCi/mi^2$
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 11, Number 2, February 1970

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of the Interior
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

CONTENTS

CONTENTS—continued

RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

John C. Villforth
Director
Bureau of Radiological Health

Address correspondence to the Editor, *Radiological Health Data and Reports*, Bureau of Radiological Health, 5600 Fisher's Lane, Rockville, Md. 20852.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Environmental Health Service
Bureau of Radiological Health

Reports

Strontium-90 and Cesium-137 in Total Diet Samples—A Comparative Study of Data

P. D. Roecklein, C. E. Smedley, and *R. E. Simpson*[1]

Six federal, State, and private organizations have published values for strontium-90 and cesium-137 activities in total diet samples for the period, January 1961 through December 1967. The data reported by these organizations have been statistically compared to determine how well the values of the several agencies agree. Our results show that there is agreement (at a significance level (α) equal to 0.05) in about 60 percent of the cases for comparable samples collected at about the same location and time and analyzed by similar methods. The 40 percent disagreement may be due to differences in samples, however, the specific sampling sites within a geographical area cannot be verified.

In 1961, the Food and Drug Administration began a surveillance program to monitor radioactivity in total diet samples (*1*). Similar programs were initiated in 1960 by the Health and Safety Laboratory (HASL) (*2*) and by the U.S. Public Health Service (*3*). In addition, several State public health agencies conducted programs locally starting in 1963 and 1964. Figure 1 shows the major sampling points throughout the country. Food categories in the total diets, in general, were based on a Department of Agriculture (USDA) study of food consumption in the United States (*4*).

A review of volumes 2 through 9 of *Radiological Health Data and Reports* showed that six total diet programs representing federal, State, and private organizations, had published sufficient data over a 7-year period so that the results could be compared. In addition to the above mentioned federal agencies, the States of California (*5*) and Connecticut (*6*), as well as the Consumers' Union (*7*), had programs that could be included in the comparison. With the exception of HASL and California, the programs monitored the radioactivity in total diets of children or teenagers, or in diets from institutions representing these age groups.

Summary of the programs

1. U.S. Food and Drug Administration, Radionuclides in Diets for Teenagers (*1, 8*), May 1961 through November 1965.

Total diet samples were collected quarterly from nine FDA districts (figure 1). Food categories included 82 different items based on the USDA diet survey for 19-year-old boys (*4*). The foods were prepared in the district dietary kitchens and the edible portions combined and slurried for analysis.

A multichannel gamma-ray spectrometer was used to analyze aliquots of the slurry for cesium-137. Analysis for strontium-90 by beta-particle counting followed the standard procedures of the HASL Manual (*9*).

2. U.S. Public Health Service, Radionuclides in Institutional Total Diet Samples (*3, 10*), January 1961 through December 1967.

[1] Mr. Simpson is head of the Radioactivity Section, Division of Food Chemistry and Technology, Bureau of Science, Food and Drug Administration; Mrs. Roecklein and Mr. Smedley, formerly with the Food and Drug Administration, were health physicists in the Radioactivity Section.

Figure 1. Location of total diet sampling stations contributing data

Monthly samples were collected from boarding schools of various economic levels in the PHS sampling areas. The samples were representative of a 7-day week diet of children ages 9–12 and teenagers 13–18. The samples were analyzed for radium–226, cerium–144, barium–140, cesium–137, iodine–131, strontium–90, strontium–89, zinc–65, potassium–40, and stable calcium at the PHS regional laboratories. The gamma radioactivity in aliquots of slurried samples was measured with a gamma-ray spectrometer. After a radiochemical separation the radiostrontium activity in the samples was obtained by use of a low-background beta-particle counter.

3. Consumers Union, Selected Results from Total Diet Studies and Radionuclide Levels in Teenage Diets (*7, 11, 12*), May 1961 through June 1964.

Under PHS contract the Consumers' Union (CU) collected 7-day-week food samples for infants and teenage boys from different cities throughout the country. The samples were prepared in the dietary kitchens of selected universities, and split samples of the slurries were forwarded to CU contractor and PHS laboratories for a "cross-check" analysis of the radionuclides listed under the PHS study above. Samples handled by the CU contracting laboratories were radiochemically processed and all radionuclides assayed by beta-particle techniques.

4. AEC Health and Safety Laboratory, Tri-City Study (*2, 13*), March 1960 through December 1967.

Samples were collected from 19 categories of food items in an average diet for the general populations of New York City, San Francisco, and Chicago. Each food item was analyzed separately for strontium–89, strontium–90, cesium–137, and stable calcium. The activity of each radionuclide was determined by beta-counting techniques after a radiochemical separation. The amounts of strontium–90 and cesium–137 in the total diet were obtained from an average of the results of the 19 categories, weighted according to the fractional contribution of these foods to the total diet.

5. California State Department of Public Health, Estimated Daily Intake of Radionuclides

in California Diets (*5, 14*), January 1964 through December 1967.

The "house" diets of participating hospitals from 20 geographic areas were taken to be representative diets of the State's population. Seven-day week food samples were collected every 2 months for analysis by the State Sanitation and Radiation Laboratory. The samples were homogenized and ashed, and aliquots of the ash were assayed for strontium–89 and strontium–90 by beta-particle counting. The ashed portion was also analyzed for stable potassium, sodium, strontium, and calcium. Aliquots of the wet slurry were analyzed for cerium–144, cerium–141, cesium–137, and zirconium–95 by gamma-ray spectrometry.

6. Connecticut State Department of Health, Estimated Daily Intake of Radionuclides in Connecticut Standard Diet (*6, 15*), March 1963 through December 1967.

This diet was intended to be representative of one day's intake by an 18-year old boy. Samples were collected monthly throughout the State and analyzed for strontium–89, strontium–90, cesium–137, and normal potassium. A gamma-ray spectrometer was used to measure cesium–137 activity; dried and ashed aliquots of the sample were assayed for strontium–89 and strontium–90 using a thin-window gas-flow counter.

Statistical analysis

Of the variety of radionuclides reported in the total diets of the six programs, strontium–90 and cesium–137 are common to all programs. The reported levels of strontium–90 and cesium–137 activities per unit weight of total diet have been used as the basis for comparison.

Since detailed information regarding the geographic source of the total diet samples was often unavailable, it was assumed that the samples were representative of the immediate area around the cities where the collecting agency was located. In the study reported here, statistical comparisons are made only for data from agencies located in the same city or in cities less than 200 miles apart. The data used in our comparison are tabulated in tables 1 and 2 according to sampling time and location.

Frequently the precision of the results reproduced in tables 1 and 2 was not reported; therefore, the data have been treated as individual values. As such, the values cannot be considered as random samples from a normal distribution, and therefore, the only comparison of the data that may be made is between pairs of values as reported by two separate sponsors in the same geographic area and having similar sampling dates. The sign test for paired observations (*16*) is a distribution-free statistical comparison applicable under very general conditions and is therefore a suitable approach for data with the limitations noted above.

The sign test was applied to the hypothesis that values for strontium–90 or cesium–137 content in total diet samples as reported by two separate agencies agree with respect to time and place of sampling. Since the composition of the food samples and the methods of analysis were similar for all the sponsors included in this study, the statistical test should give a valid indication of significant differences in strontium–90 and cesium–137 activities reported. Initially the test was applied at the 0.25 level of significance; at this level there is a 25-percent chance of concluding that two sets of values differ when in actuality they do not. The test was repeated at the 0.10 and 0.05 levels where there are 10 percent and 5-percent chances, respectively, of concluding the values disagree when they actually do not. Tables 3 and 4 tabulate the results of the sign test.

The Wilcoxon signed-ranks test is a more powerful statistical test; however, it requires the assumption that the data are from a symmetrical distribution. While this assumption may be reasonable, in this case it cannot be proven. Assuming, however, that this requirement is satisfied the Wilcoxon signed-ranks test was applied to the data sets and, with a few exceptions, confirmed the results of the sign test at the 0.05 significance level as indicated in tables 3 and 4.

Discussion

The results of our statistical study of strontium–90 and cesium–137 data include comparisons of data reported by the same agency for different cities and comparisons of data reported by different agencies within the same city. For the purpose of this study it was arbitrarily assumed that data accumulated in cities no more than 200 miles apart should agree. However, the data in tables 3 and 4 indicate that, at the 0.05 significance level,

Table 1. Strontium-90 radioactivity

Area		Program[a]	1961											
			Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Vt:	Burlington	1 PHS												
Maine:	Portland	2 PHS												
		3 CU												
Mass:	Boston	4 PHS										7	8	
		5 FDA												
		6 CU					4							
R.I:	Providence	7 PHS												
Conn:	Hartford	8 PHS												
		9 CONN												
N.Y:	New York City	10 PHS	5	2	5	4	3	3		7	4	3	6	5
		11 HASL		5			6			5			6	
		12 CU					4							
N.J:	Trenton	13 PHS												
Del:	Wilmington	14 PHS												
Md:	Baltimore	15 PHS												
D.C:	Washington	16 FDA					4			4			4	
Va:	Norfolk	17 PHS												
N.Y:	Buffalo	18 CU												
Ohio:	Cleveland	19 PHS												
Mich:	Detroit	20 PHS												
Pa:	Pittsburgh	21 PHS												
W. Va:	Charleston	22 PHS												
Wisc:	Milwaukee	23 PHS												
Ill:	Chicago	24 PHS					4					6	4	
		25 HASL				5			3			3		
		26 CU					3							
Ind:	Indianapolis	27 PHS												
Ky:	Louisville	28 PHS												
N.C:	Charlotte	29 PHS												
S.C:	Charleston	30 PHS												
Tenn:	Knoxville	31 CU					5							
Ga:	Atlanta	32 PHS			5	5	4	7	4	3	4	5	4	3
		33 FDA												
Ala:	Montgomery	34 PHS												
Miss:	Columbia	35 PHS												
La:	New Orleans	36 PHS												
		37 CU					3							
Ark:	Little Rock	38 PHS												
		39 CU												
Tenn:	Memphis	40 PHS										7	7	5
Mo:	St. Louis	41 PHS	7	6	2	3	3	1	3			2	5	
		42 FDA												
		43 CU												
Iowa:	Des Moines	44 PHS												
Nebr:	Omaha	45 PHS												
S.Dak:	Sioux Falls	46 PHS												
		47 CU					3							
Minn:	Minneapolis	48 PHS												
		49 FDA												
	Duluth	50 CU												
Kans:	Wichita	51 PHS												
Okla:	Oklahoma City	52 PHS												
Tex:	Dallas	53 FDA												
	Austin	54 PHS		4	4	4	4	2	6	5	6	4	3	2
Wyo:	Laramie	55 PHS												
Colo:	Denver	56 PHS	3	6	1	2	3	2	2	4	3	7	6	4
		57 FDA												
Idaho:	Idaho Falls	58 PHS												
Utah:	Salt Lake City	59 PHS											5	1
		60 CU												
Wash:	Seattle	61 PHS		6	2	4	1	3	1	3	3	3	6	0
		62 FDA												
Ore:	Portland	63 PHS												
		64 CU												
Nev:	Carson City	65 PHS												
Calif:	Sacramento	66 CAL												
	Berkeley	67 CAL												
	San Francisco	68 PHS												
		69 FDA												
		70 HASL	2			2		2			1			2
		71 CU												
	Santa Barbara	72 CAL												
	Los Angeles	73 PHS		3	1	2	2	2	5	2	4	1	14	1
		74 CU					2							
		75 CAL												
	San Diego	76 CAL												
	Needles	77 CAL												
Ariz:	Phoenix	78 PHS												

See footnotes at end of table.

in total diet samples (pCi/kg)

Program	1962 Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	1963 Jan	Feb	Mar	Apr	May	June
1 PHS																		
2 PHS																		
3 CU			5			9								8		10		13
4 PHS	6	6	7	5	2	1	1	8	6	9	9	19	14	14	17	13		26
5 FDA																		
6 CU	5		8		6	8												
7 PHS																		
8 PHS																		
9 CONN															9			
10 PHS	4		4	4	3	1	5							15		10	16	
11 HASL				6		6		8			9			10			20	
12 CU	4		5		7	8								6	7	7	8	14
13 PHS																		
14 PHS																		
15 PHS																		
16 FDA		6			6			7			8			12			11	
17 PHS	6	7	6	9	8	11	8	6	12	13	8	12	12	9	11	13	14	17
18 CU	4				6									6		7		15
19 PHS	5	5	4	4	6	1	4	3	5	1	7	3	9	13	20	11		17
20 PHS																		
21 PHS																		
22 PHS																		
23 PHS																		
24 PHS				3	8	2	1	6	1									
25 HASL		4		5			7			8			8			8		
26 CU	3		4		3	5								7	7	7	8	12
27 PHS																		
28 PHS																		
29 PHS																		
30 PHS																		
31 CU	5		8		14	10								9	8	12	17	24
32 PHS	4	5	5	9	8	7	9	8	8	10	7	9	10	12	10	10	17	16
33 FDA					10			7			9			13			10	
34 PHS																		
35 PHS																		
36 PHS	9	9	12	12	16	15	14	12	13	17	12	13	15	11	30	23	24	14
37 CU	10		15		13	19								16	23	23	15	14
38 PHS																		
39 CU	3				5									13	15	18	23	25
40 PHS	6	4	9	9	12	7	13	12	7	14	8	10	6	12	13	17	14	20
41 PHS			6	5	3	10	14	13							10	14	36	11
42 FDA					10			9			9			7			8	
43 CU														8		8		19
44 PHS																		
45 PHS	2	4	1	1	5	2	9	10		11	5	9	12		4	11	14	32
46 PHS																		
47 CU	3		4		4	10								8	9	10	9	14
48 PHS				3	1	10	9	10	16	12	2	6	6	6	8	13	11	22
49 FDA					5			9			8			9			10	
50 CU														10	12	12	11	19
51 PHS																		
52 PHS																		
53 FDA																	13	
54 PHS	5	5	5	4	6	7	6	7	9	6	5	7	9	10	9	10	12	10
55 PHS																		
56 PHS		4	3	3	1	23	10	13	12	10	7	24	8	13	8		12	13
57 FDA																	7	
58 PHS																		
59 PHS	3	3	3	3	2				7	6	8	7	7	9	5	6	6	
60 CU	3				3													
61 PHS	3	4	7	4	9	12	12	9	9	7	23	17	9	12	11	11	16	15
62 FDA																	10	
63 PHS																		
64 CU	3				8									11	10	15	31	22
65 PHS																		
66 CAL																		
67 CAL																		
68 PHS																		
69 FDA					3			3			5			8			9	
70 HASL				3		3			3			4			5			10
71 CU	2				3									5	8	11	11	11
72 CAL																		
73 PHS	1	2	3	2	1						8	2	3	2	2	5	5	
74 CU	3		4		1	2								3	3	5	5	6
75 CAL																		
76 CAL																		
77 CAL																		
78 PHS																		

See footnotes at end of table.

Table 1. Strontium-90 radioactivity

Area		Program[a]	1963						1964					
			July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Vt:	Burlington	1 PHS										14	16	28
Maine:	Portland	2 PHS										22	20	23
Mass:	Boston	3 CU			19									
		4 PHS	12	30	26	16	28	23	23	26	19	23	17	33
		5 FDA					13						7	
		6 CU												
R.I:	Providence	7 PHS												
Conn:	Hartford	8 PHS												
		9 CONN	14	13	16	16	13	17	15	13	16	14	12	16
N.Y:	New York City	10 PHS	17		18	14	26	20	19		16	15		
		11 HASL		20			19			17			20	
		12 CU	25	20	40					16		13		16
N.J:	Trenton	13 PHS												
Del:	Wilmington	14 PHS									15	17	26	17
Md:	Baltimore	15 PHS												25
D.C:	Washington	16 FDA		11			13			17			15	
Va:	Norfolk	17 PHS	13	12	12	16	16	15	12	13	11	16	15	18
N.Y:	Buffalo	18 CU			16					13		15		20
Ohio:	Cleveland	19 PHS	17	44	13	32	14	16	12	16	12	13	13	17
Mich:	Detroit	20 PHS												17
Pa:	Pittsburgh	21 PHS										14	19	22
W. Va:	Charleston	22 PHS												
Wisc:	Milwaukee	23 PHS											15	19
Ill:	Chicago	24 PHS	56	14	14	14	18	21	15	16	15	15	19	15
		25 HASL	11			15			14			14		
		26 CU	12	12	11					12		11		11
Ind:	Indianapolis	27 PHS												19
Ky:	Louisville	28 PHS												23
N.C:	Charlotte	29 PHS												27
S.C:	Charleston	30 PHS												16
Tenn:	Knoxville	31 CU	29	24	27					16		16		23
Ga:	Atlanta	32 PHS	6	19	14	16	17	19	13	16	11			21
		33 FDA		18			19			25			28	
Ala:	Montgomery	34 PHS												14
Miss:	Columbia	35 PHS							23	25	35	38	34	33
La:	New Orleans	36 PHS	16	20	20	20	23	21	21	26	31	34	31	25
		37 CU	23	23	21					23		26		24
Ark:	Little Rock	38 PHS										23	39	28
		39 CU	29	23	23									
Tenn:	Memphis	40 PHS	15	20	24	18	16	19	22	12	20	29	24	18
Mo:	St. Louis	41 PHS		4	23	11	15	2	17	33	15	24	22	24
		42 FDA		17			16			10			15	
		43 CU			19					13		10	16	18
Iowa:	Des Moines	44 PHS												19
Nebr:	Omaha	45 PHS	16	14	1	13	12	17	15	17	22	22	22	20
S. Dak:	Sioux Falls	46 PHS												
		47 CU	19	31	12									
Minn:	Minneapolis	48 PHS	17	10	11	12	10	1	15	14	19	19	10	35
		49 FDA		18			15			13			12	
	Duluth	50 CU	17	17	14									
Kans:	Wichita	51 PHS												14
Okla:	Oklahoma City	52 PHS											17	15
Tex:	Dallas	53 FDA		10			13			13			14	
Tex:	Austin	54 PHS	13	12	11	10	14	12	9	10	10	6	8	10
Wyo:	Laramie	55 PHS										15	18	32
Colo:	Denver	56 PHS	32	17	6	10	9	1	11	12	13	16	13	14
		57 FDA		7			10			12			14	
Idaho:	Idaho Falls	58 PHS											40	31
Utah:	Salt Lake City	59 PHS			12	14	4	16	12	14	16	41	27	14
		60 CU								14		13		14
Wash:	Seattle	61 PHS	13	16	17	21	14	14	16	14	16	43	27	25
		62 FDA		10			16			13			17	
Ore:	Portland	63 PHS												
		64 CU	24	15	15					15		18		20
Nev:	Carson City	65 PHS												
Calif:	Sacramento	66 CAL								[b] 8		[b] 6		[b] 5
	Berkeley	67 CAL								[b] 7		[b] 10		[b] 5
	San Francisco	68 PHS												
		69 FDA		6			6			7			7	
		70 HASL			7			8			9			9
		71 CU	7	8	6									
	Santa Barbara	72 CAL								[b] 2		[b] 8		[b] 8
	Los Angeles	73 PHS		10		4	7	6	6	8	14	9	7	10
		74 CU	6	4	4					6		6		8
		75 CAL								[b] 3		[b] 5		[b] 4
	San Diego	76 CAL										[b] 1		[b] 10
	Needles	77 CAL								[b] 11				[b] 6
Ariz:	Phoenix	78 PHS												

See footnotes at end of table.

in total diet samples (pCi/kg)—Continued

Program[a]	1964 July	1964 Aug	1964 Sept	1964 Oct	1964 Nov	1964 Dec	1965 Jan	1965 Feb	1965 Mar	1965 Apr	1965 May	1965 June	1965 July	1965 Aug	1965 Sept	1965 Oct	1965 Nov	1965 Dec
1 PHS	20	19	12	10	13	13	14	15	14	14	16	16	13	20	10	11	10	14
2 PHS	21	23	15	18	17	19	17	13	17	12	15	17						
3 CU																		
4 PHS	18	21	14	15	16	15	19	12	18	11	9	14	10	12	10	9	10	7
5 FDA		17			8									11			12	
6 CU																		
7 PHS							15	12		12	8	13						
8 PHS	14	12	10	8	9	13	12	14	11	9	11	12						
9 CONN	15	19	15	14	12	12	13	11	15	14	18	15		14	13	16	11	11
10 PHS						11	14	16	12	12	18							
11 HASL		17			16			14			17			12			13	
12 CU	20																	
13 PHS		16	9	10	11	10	11	12	10	10	13	18						
14 PHS	13	14	17	13	13	11	12	12	14	12	12	14	14	10	13		10	11
15 PHS	21	18	18	15	15	15	15	14	14	14	17	18						
16 FDA		11						11			13			11			8	
17 PHS	18	16	13	17	20	14	17	15	14	14	21	14						
18 CU	18																	
19 PHS	14	12	12	12	12	12	12	10	13	15	10	11	12	8	9	6	6	12
20 PHS	11	13	8	10	10	12	13	13	12	12	8	7						
21 PHS	17	16	14	17	18	14	15	19	15	14	13	16	10	12	8	10	15	13
22 PHS	23	23	18	20	25	27	22	17	16	23	19	18						
23 PHS	8	13	11	8	9	8	9	10	11	11	10	11						
24 PHS	14	15	8	9	12	12	12	15	14	9	13	11	9	9	9	15	9	8
25 HASL	13			12			10			12			9			9		
26 CU	12																	
27 PHS	15	11	14	11	11	9	11	14	11	14	13	12						
28 PHS	14	24	19	25	14	21	19	19	16	18	13	16	12	12	19	14	15	15
29 PHS	19	26	28	25	32	21	14	19	14	13	17	14						
30 PHS	16	12	22	17	19		25	14	16	19	21	14	15	20	18	18	16	21
31 CU	22																	
32 PHS	21	18	19	26	27	28	16	19	19	18	19	18						
33 FDA		20			21						17			12			12	
34 PHS	13	12	9	13	15	17	11	14	11	12	14	10						
35 PHS	34	27	28	41	33	23	26	18	22	23	22	18						
36 PHS	31	26	21	22	21	25	17	13	19	19	18	19	24	17	22	14	19	16
37 CU	27																	
38 PHS	22	21	29	28	19	27	20	20	22	28	24	19	26	17	24	20	12	20
39 CU																		
40 PHS	23	29	20	13	16	14	16	13	14	22	17	16						
41 PHS	18	17	6	22	20	15	38	22	27	15	25	16	14	13	11	12	10	11
42 FDA		18			8						12			12			0	
43 CU																		
44 PHS	23	19	18	22	15	14	13	13	14	17	15	12						
45 PHS	22	18	21	16	23	13	19	25	21	22	20	16						
46 PHS						19	19	22	13	8	15	22	17	16	12	16	15	19
47 CU																		
48 PHS	17	17						53	38	17	24	19						
49 FDA		10			9			14			16			14			17	
50 CU																		
51 PHS	14	12	17	9	10	14	15	16	16	19	12	12						
52 PHS	8	8	15	14	16	16	16	11	14	12	12	10						
53 FDA		11			10			8			11			8			8	
54 PHS	10	16	11	8	15	10	8	8	6	8	8	6	8	8	12	6	8	8
55 PHS	20	22	13	12	13	15	12	16	14	13	18	19						
56 PHS	16	16	7	16	8	10	18	20	19	17	12	17	11	9	8	8	11	16
57 FDA		11			7			9			17			19			24	
58 PHS	22	20	24	13		16	16	36	25	27	29	20	34	12	9	17	14	10
59 PHS			21	15	6	14	9	14	16	13	18	15						
60 CU	13																	
61 PHS	26	22	11	15	32	21	36	18	20	19	34	18	20	23	15	26	12	15
62 FDA		13			14			11			17			8			9	
63 PHS	13	12	20	11	10	11	16	24	10	9	17	14						
64 CU	17																	
65 PHS			23	10	10	17	11	46	25	9	7	11						
66 CAL		[b] 9		[b] 6		[b] 6		[b] 4		[b] 1		[b] 8		[b] 6		[b] 5		[b] 6
67 CAL		[b] 7		[b] 13		[b] 4		[b] 8		[b] 5		[b] 7		[b] 4		[b] 5		[b] 5
68 PHS										11	18	9						
69 FDA		6			6			6			6			5			4	
70 HASL			6			6			8			7			5			5
71 CU																		
72 CAL		[b] 13		[b] 8				[b] 7		[b] 9		[b] 5		[b] 7		[b] 3		
73 PHS				8	8	18	8	17	13	5	7	7	9	7	6	4	6	11
74 CU	5																	
75 CAL		[b] 4		[b] 10		[b] 4		[b] 5		[b] 3		[b] 4		[b] 3		[b] 3		[b] 4
76 CAL		[b] 2		[b] 4		[b] 6		[b] 4		[b] 6		[b] 6		[b] 6		[b] 3		[b] 4
77 CAL		[b] 11		[b] 17		[b] 7		[b] 4		[b] 5		[b] 4		[b] 5		[b] 5		[b] 7
78 PHS							18	28	20	18	19	11	6	2	13	13	8	14

Table 1. Strontium-90 radioactivity

Area		Program[a]	1966 Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Vt:	Burlington	1 PHS	12	13	11	11	16	13	15	7	9
Maine:	Portland	2 PHS									
		3 CU									
Mass:	Boston	4 PHS	8	7	7	8	7	9	9		8
		5 FDA									
		6 CU									
R.I:	Providence	7 PHS									
Conn:	Hartford	8 PHS									
		9 CONN	11	12	12	14	10	16	10	9	9
N.Y:	New York City	10 PHS									
		11 HASL		11			12			11	
		12 CU									
N.J:	Trenton	13 PHS									
Del:	Wilmington	14 PHS	11	10	11	9	10	11		10	10
Md:	Baltimore	15 PHS									
D.C:	Washington	16 FDA					14			10	
Va:	Norfolk	17 PHS									
N.Y:	Buffalo	18 CU									
Ohio:	Cleveland	19 PHS	9	9	11	10	7	11	7	7	9
Mich:	Detroit	20 PHS									
Pa:	Pittsburgh	21 PHS	12	10	10	10	9	11	12	9	9
W. Va:	Charleston	22 PHS									
Wisc:	Milwaukee	23 PHS									
Ill:	Chicago	24 PHS	7	9	9	8	8	12	6	6	6
		25 HASL	11			9			9		
		26 CU									
Ind:	Indianapolis	27 PHS									
Ky:	Louisville	28 PHS	12	16	14	13	16	19			13
N.C:	Charlotte	29 PHS									
S.C:	Charleston	30 PHS	20	13	15	13	12	14	12	14	14
Tenn:	Knoxville	31 CU									
Ga:	Atlanta	32 PHS									
		33 FDA									
Ala:	Montgomery	34 PHS									
Miss:	Columbia	35 PHS									
La:	New Orleans	36 PHS	19	16	17	18	21	22	16	18	16
Ark:	Little Rock	37 CU									
		38 PHS	12	20	14	12	14	18	18	15	18
		39 CU									
Tenn:	Memphis	40 PHS									
Mo:	St. Louis	41 PHS	10	11	11	10	12	17			
		42 FDA					11			10	
		43 CU									
Iowa:	Des Moines	44 PHS									
Nebr:	Omaha	45 PHS									
S. Dak:	Sioux Falls	46 PHS	14	13	14	17	14	12	13		
		47 CU									
Minn:	Minneapolis	48 PHS									
		49 FDA									
	Duluth	50 CU									
Kans:	Wichita	51 PHS									
Okla:	Oklahoma City	52 PHS									
Tex:	Dallas	53 FDA									
Tex:	Austin	54 PHS	8	7	7	6	6	10	7	8	7
Wyo:	Laramie	55 PHS									
Colo:	Denver	56 PHS	15	10	12	11	16	8	8	8	11
		57 FDA									
Idaho:	Idaho Falls	58 PHS	9	16	11	8	25	6	6	9	9
Utah:	Salt Lake City	59 PHS									
		60 CU									
Wash:	Seattle	61 PHS	10	17	12	20	18	29	15		15
		62 FDA									
Ore:	Portland	63 PHS									
		64 CU									
Nev:	Carson City	65 PHS									
Calif:	Sacramento	66 CAL		[b] 6		[b] 4		[b] 4		[b] 5	
	Berkeley	67 CAL		[b] 3		[b] 5		[b] 3		[b] 4	
	San Francisco	68 PHS									
		69 FDA					4			4	
		70 HASL			5			3			3
		71 CU									
	Santa Barbara	72 CAL		[b] 5		[b] 7		[b] 4		[b] 4	
	Los Angeles	73 PHS	7	8	16	7	12	6	6	6	11
		74 CU									
		75 CAL		[b] 6		[b] 4		[b] 5		[b] 3	
	San Diego	76 CAL		[b] 1		[b] 4		[b] 3		[b] 3	
	Needles	77 CAL		[b] 5		[b] 5		[b] 3		[b] 5	
Ariz:	Phoenix	78 PHS	10	14	11	7	11	12	10	4	6

[a] Agency symbols identified in figure 1. See beginning of table for a breakdown of area by using the program code.
[b] Bimonthly samples include preceding month.

in total diet samples (pCi/kg)—Continued

Program[a]	1966			1967											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1 PHS	12	12	10	13	12	11	13	11	8		16	12			
2 PHS													10	10	14
3 CU															
4 PHS	11	10	11	11	12	10	10	11	11	11		10	9	8	13
5 FDA															
6 CU															
7 PHS															
8 PHS															
9 CONN	13	9	11	10	9		10	8	11	9		13	10		8
10 PHS															
11 HASL		7			8			10			10			10	
12 CU															
13 PHS															
14 PHS	10	11	8	10	9	10	9	8	12	16	9	10	10	8	7
15 PHS															
16 FDA		11			12										
17 PHS															
18 CU															
19 PHS	7	7	8	9	7	8	7	9	7	8	8	5	6	6	7
20 PHS															
21 PHS	9	10	9	8	8	7	10	7	10	6	7	7	6	8	8
22 PHS															
23 PHS															
24 PHS	7	7	8	7	7	7	7	8	8	7	8	5	5	7	7
25 HASL	5			8			7			7			6		
26 CU															
27 PHS															
28 PHS	8	11	10	9	10	12	11	12	12	8	9	7	9	9	9
29 PHS															
30 PHS	16	11	14	13	15	12	9	11	8	9	8	11	9	11	12
31 CU															
32 PHS															
33 FDA															
34 PHS															
35 PHS										6	10	9	11	14	12
36 PHS	17	17	9	13	13	17	12	14	10	11	12	13	10	12	12
37 CU															
38 PHS	13	11	15	13	13	13	10	14	13	20	17	15	10	9	10
39 CU															
40 PHS															
41 PHS		11	8	10	11	11	11	15	14					12	8
42 FDA		9													
43 CU															
44 PHS															
45 PHS										6	8	6	7	6	5
46 PHS		6	5	5	6	17	6	8	6	7	7	5	7	5	4
47 CU															
48 PHS															
49 FDA															
50 CU															
51 PHS															
52 PHS															
53 FDA															
54 PHS	7	7	7	8	6	5	5	5	5	3	8	5	4	6	7
55 PHS															
56 PHS	7	9	6	7	8	8	7	7	6	6	6	4	8	3	7
57 FDA															
58 PHS	12	9	13	11	11	8	8	7	2	6	14	9	7	7	7
59 PHS										4	4	4	6	6	5
60 CU															
61 PHS	18	16	7	8	10	6	8	11	7		7	6	5	6	4
62 FDA															
63 PHS										5	5	4	6	5	3
64 CU															
65 PHS										5	4	6	6	3	6
66 CAL	[b]4		[b]2		[b]3		[b]4		[b]4		[b]3		[b]2		
67 CAL	[b]4		[b]3		[b]3		[b]2		[b]2		[b]2		[b]3		
68 PHS										6	3	6	3	11	4
69 FDA		3			3										
70 HASL			2			4			4			2			2
71 CU															
72 CAL	[b]3		[b]5		[b]4		[b]2		[b]2		[b]4		[b]2		
73 PHS	6	6	6	5	5	4	4	5	5	4	6	4	3	3	6
74 CU															
75 CAL	[b]5		[b]3		[b]3		[b]5		[b]4		[b]2		[b]2		
76 CAL	[b]6		[b]3		[b]3				[b]2		[b]2		[b]2		
77 CAL	[b]3		[b]3		[b]3		[b]2		[b]2		[b]3		[b]2		
78 PHS	9	7	5	6	5	3	7	4	7	4	3	8	12	11	

Table 2. Cesium-137 radioactivity in

Area		Program[a]	1961 Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Vt:	Burlington	1 PHS												
Maine:	Portland	2 PHS												
		3 CU												
Mass:	Boston[b]	4 PHS										15	5	
		5 FDA												
R.I:	Providence	6 PHS												
Conn:	Hartford	7 PHS												
		8 CONN												
N.Y:	New York City	9 PHS	46	2	5		14	8		10	14	5	5	5
		10 HASL												
		11 CU					28							
N.J:	Trenton	12 PHS												
Del:	Wilmington	13 PHS												
Md:	Baltimore	14 PHS												
D.C:	Washington	15 FDA												
Va:	Norfolk	16 PHS												
N.Y:	Buffalo	17 CU												
Ohio:	Cleveland	18 PHS												
Mich:	Detroit	19 PHS												
Pa:	Pittsburgh	20 PHS												
W.VA:	Charleston	21 PHS												
Wisc:	Milwaukee	22 PHS												
Ill:	Chicago	23 PHS					16					5	6	
		24 HASL												
		25 CU					45							
Ind:	Indianapolis	26 PHS												
Ky:	Louisville	27 PHS												
N.C:	Charlotte	28 PHS												
S.C:	Charleston	29 PHS												
Tenn:	Knoxville	30 CU					41							
Ga:	Atlanta	31 PHS			6	13	6	19	8	5	5	10	5	5
		32 FDA												
Ala:	Montgomery	33 PHS												
Miss:	Columbia	34 PHS												
La:	New Orleans	35 PHS												
		36 CU					40							
Ark:	Little Rock	37 PHS												
		38 CU												
Tenn:	Memphis	39 PHS										14	5	5
Mo:	St. Louis	40 PHS	5	6	5	4	22	11	10			10	10	
		41 FDA												
		42 CU												
Iowa:	Des Moines	43 PHS												
Nebr:	Omaha	44 PHS												
S.Dak:	Sioux Falls	45 PHS												
		46 CU					26							
Minn:	Minneapolis	47 PHS												
		48 FDA												
Minn:	Duluth	49 CU												
Kans:	Wichita	50 PHS												
Okla:	Oklahoma City	51 PHS												
Tex:	Dallas	52 FDA												
	Austin	53 PHS		5	5	9	5	9	5	5	5	5	5	5
Wyo:	Laramie	54 PHS												
Colo:	Denver	55 PHS	5	5	8	10	35	11	10	20	5	5	5	10
		56 FDA												
Idaho:	Idaho Falls	57 PHS												
Utah:	Salt Lake City	58 PHS											5	10
		59 CU												
Wash:	Seattle	60 PHS		4	12	5	22	18	20	15	20	15	15	15
		61 FDA												
Ore:	Portland	62 PHS												
		63 CU												
Nev:	Carson City	64 PHS												
Calif:	Sacramento	65 CAL												
	Berkeley	66 CAL												
	San Francisco	67 PHS												
		68 FDA												
		69 HASL												
		70 CU												
	Santa Barbara	71 CAL												
	Los Angeles	72 PHS		5	5	4	4	5	20	15	10	5	5	5
		73 CU					16							
		74 CAL												
	San Diego	75 CAL												
	Needles	76 CAL												
Ariz:	Phoenix	77 PHS												

See footnotes at end of table.

total diet samples (pCi/kg)

Program[a]	1962												1963							
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
1 PHS																				
2 PHS																				
3 CU			61			154								35		60		90		
4 PHS	25	5	9	25	35	76	108	41	27	65	118	117	94	81	91	81	68	125	155	216
5 FDA																				
6 PHS																				
7 PHS																				
8 CONN															60				80	130
9 PHS	5		6	10	4	50	30							51		66	65		75	
10 HASL											34									
11 CU	51		57		68	132								45	30	50	45	79	116	120
12 PHS																				
13 PHS																				
14 PHS																				
15 FDA					12			39			37			51			73			74
16 PHS	5	5	7	15	45	14	14	29	34	34	30	34	33	34	33	59	39	41	53	53
17 CU	31				48									50		50		70		
18 PHS	5	5	10	14	16	57	130	20	18	56	46	79	69	55	42	58	61	83	84	98
19 PHS																				
20 PHS																				
21 PHS																				
22 PHS																				
23 PHS				5	12	99	37	6	113										81	78
24 HASL										31										
25 CU	37		60		46	127								29	40	41	45	70	76	84
26 PHS																				
27 PHS																				
28 PHS																				
29 PHS																				
30 CU	39		68		143	167								25	35	44	40	79	105	125
31 PHS	5	16	24	35	7	28	12	33	35	6	19	30	29	40	39	38	113	78	66	101
32 FDA					29			16			23			46			128			78
33 PHS																				
34 PHS																				
35 PHS	7	14	24	40	64	44	20	40	44	40	30	50	54	70	90	105	100	102	85	115
36	107		159		153	325								50	70	65	80	50	70	
37 PHS																				
38 CU	29				68									34	51	69	79	100	100	106
39 PHS	5	5	6	15	5	10	12	19	12	11	21	24	41	40	49	38	41	65	76	62
40 PHS			2	2	5	25	40	34							39	34	288	80		55
41 FDA					33			13			34			31						80
42 CU														35		30		80		
43 PHS																				
44 PHS	5	10	5	3	6	3	16	40		24	21	33	59		41	89	70	76	61	74
45 PHS																				
46 CU	32		43		77	141								55	45	55	46	80	79	
47 PHS				3	3	36	36	55	30	40	40	37	50	55	67	64	48	90	80	101
48 FDA					13			31			28			62			114			109
49 CU			53			285								60	60	75	50	105	90	95
50 PHS																				
51 PHS																				
52 FDA																	100			68
53 PHS	13	5	14	27	55	22	15	19	20	19	40	39	50	24	30	50	37	52	58	53
54 PHS																				
55 PHS		10	10	2	10	6	74	10	43	50	45	101	69	61	73		60	55	85	34
56 FDA																	79			94
57 PHS																				
58 PHS	5	10	15	4	3				55	49	53	56	55	99	80	42	64			
59 CU	21				26															
60 PHS	10	10	10	12	40	45	55	75	40	40	39	59	70	76	70	60	99	96	111	116
61 FDA																	113			106
62 PHS																				
63 CU	34				252									40	45	61	115	111	169	94
64 PHS																				
65 CAL																				
66 CAL																				
67 PHS																				
68 FDA					1			14			9			16			76			42
69 HASL												18								
70 CU	29				53									10	30	49	49	65	70	96
71 CAL																				
72 PHS	15	5	3	3	3						4	15	24		25	31	30			33
73 CU	52		47		23	24								10	24	20	20	35	35	45
74 CAL																				
75 CAL																				
76 CAL																				
77 PHS																				

See footnotes at end of page.

Table 2. Cesium-137 radioactivity in

Program[a]	1963 Sept	1963 Oct	1963 Nov	1963 Dec	1964 Jan	1964 Feb	1964 Mar	1964 Apr	1964 May	1964 June	1964 July	1964 Aug	1964 Sept	1964 Oct	1964 Nov	1964 Dec
1 PHS								115	125	140	105	95	85	70	75	90
2 PHS								140	130	125	150	130	95	90	105	100
3 CU	121															
4 PHS	190	129	188	172	215	200	170	165	150	200	155	125	110	105	90	115
5 FDA			99			119			108			92			96	
6 PHS																
7 PHS											90	100	70	70	70	90
8 CONN	120	100	110	140	140	110	150	160	90	120	130	110	100	100	80	70
9 PHS	86	76	100	129	85		115	115								75
10 HASL			85													
11 CU	110					82		98	92	117						
12 PHS												55	50	85	70	10
13 PHS							110	120	145	105	70	70	70	85	65	65
14 PHS										95	80	55	45	50	50	60
15 FDA			55			82			97			59				
16 PHS	73	50	63	66	60	60	60	65	60	75	60	50	55	55	60	45
17 CU	85					95		96	96	100						
18 PHS	73	63	75	102	95	100	105	100	100	95	80	80	70	65	70	60
19 PHS										95	75	90	70	75	65	70
20 PHS								110	100	100	85	80	65	75	80	70
21 PHS											60	60	40	65	70	70
22 PHS									110	95	85	75	70	70	60	65
23 PHS	98	66	105	121	120	110	120	100	110	90	85	75	70	65	70	70
24 HASL		63														
25 CU	70					77		85	88	71						
26 PHS										80	60	60	60	55	60	75
27 PHS										55	40	45	30	30	40	45
28 PHS										70	45	50	45	55	55	55
29 PHS										105	55	60	75	50	80	
30 CU	69					85		99	120	78						
31 PHS	91	66	77	76	60	55	55			75	55	50	65	70	60	60
32 FDA			63			91			125			51			83	
33 PHS										50	50	40	50	45	45	50
34 PHS					110	120	200	230	190	135	105	85	65	75	90	70
35 PHS	95	94	116	120	110	140	140	110	115	85	80	65	60	50	60	45
36 CU	65					96		128	95	84						
37 PHS								85	115	75	50	60	45	50	50	35
38 CU	74															
39 PHS	51	48	76	60	65	55	65	60	55	50	40	40	40	40	25	45
40 PHS	60	70	69	79	60	75	70	70	65	55	50	55	55	55	45	80
41 FDA						67			83			39			55	
42 CU	40					74		85	80	77						
43 PHS										65	55	60	60	60	45	55
44 PHS	59	81	70	71	65	70	80	100	125	60	70	50	45	40	45	55
45 PHS																90
46 CU	65															
47 PHS	86	79	86	80	95	110	110	100	75	95	75	80				
48 FDA			83			103			87			102			68	
49 CU	90															
50 PHS										70	30	80	45	35	40	35
51 PHS									65	55	35	20	45	40	45	40
52 FDA			44						56			40			56	
53 PHS	31	51	67	59	45	45	30	30	50	40	35	25	35	30	30	25
54 PHS								90	65	80	65	60	55	55	65	80
55 PHS	55	74	54	45	65	70	50	80	60	65	90	70	50	50	30	55
56 FDA			57			70			84			59			37	
57 PHS									180	195	125	95	120	50		100
58 PHS	40	123	119	175	135	140	140	155	125	90			80	75	50	85
59 CU						124		140	122	119						
60 PHS	120	99	121	84	110	90	100	90	90	110	140	120	120	85	95	100
61 FDA			95			64			104			86			97	
62 PHS											55	55	70	55	55	80
63 CU	85					165		160	165	131						
64 PHS													50	45	55	50
65 CAL						[d]30		[d]33		[d]25		[d]16		[d]30		[d]34
66 CAL						[d]31		[d]33		[d]21		[d]20		[d]24		[d]22
67 PHS																
68 FDA			57			63			63			34			43	
69 HASL				150												
70 CU	40															
71 CAL								[d]33				[d]26		[d]20		
72 PHS		50	60	50	65	70	50	50	55	50				55	20	35
73 CU	45					55		50	65	41						
74 CAL								[d]32		[d]23		[d]17		[d]42		[d]28
75 CAL						[d]22		[d]20		[d]32		[d]21		[d]35		[d]18
76 CAL						[d]56				[d]27		[d]30		[d]25		[d]25
77 PHS																

See footnotes at end of table.

total diet samples (pCi/kg)—Continued

Program[a]	1965												1966					
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
1 PHS	80	90	90	95	100	60	65	60	40	40	40	40	65	40	45	50	55	40
2 PHS	100	85	95	85	95	70												
3 CU																		
4 PHS	115	80	105	65	95	65	40	50	35	30	35	40	45	25	35	25	35	30
5 FDA		50			64			51			41							
6 PHS	80	75		85	80	60												
7 PHS	95	90	65	80	80	50												
8 CONN	70	60	80	70	120	70	60	70	50	60	50	30	50	30	60	40	30	40
9 PHS	90	70	65	75	70													
10 HASL		103			104						77							
11 CU																		
12 PHS	60	65	70	65	45	50												
13 PHS	60	80	80	55	55	55	50	30	35		25	40	35	40	40	25	25	25
14 PHS	40	50	50	45	60	50												
15 FDA		49			55			35			24							
16 PHS	45	40	40	55	45	35												
17 CU																		
18 PHS	85	70	70	65	55	75	40	40	50	25	35	60	35	55	40	80	40	30
19 PHS	70	65	85	75	70	55												
20 PHS	70	75	60	70	60	60	35	40	40	40	30	35	45	30	30	35	40	25
21 PHS	65	70	50	60	45	45												
22 PHS	65	80	60	75	70	55												
23 PHS	85	80	85	70	75	60	50	30	40	50	40	45	45	45	40	35	40	30
24 HASL	86			79			56			66								
25 CU																		
26 PHS	60	70	70	65	55	40												
27 PHS	50	40	35	35	25	30	35	30	30	30	30	25	25	25	30	25	55	30
28 PHS	50	40	35	50	50	20												
29 PHS	75	60	70	65	75	50	40	55	55	40	40	40	45	40	35	25	25	50
30 CU																		
31 PHS	65	70	70	75	50	45												
32 FDA		52			47			38			36							
33 PHS	45	40	45	25	50	25												
34 PHS	75	70	70	75	70	60												
35 PHS	100	55	60	55	50	40	45	40	40	35	45	40	35	40	30	40	35	45
36 CU																		
37 PHS	50	45	40	40	45	30	40	25	30	25	25	25	20	30	20	25	30	25
38 CU																		
39 PHS	40	35	40	45	35	40												
40 PHS	45	55	80	30	30	25	30	25	45	30	35	30	40	30	35	30	30	35
41 FDA		35			28													
42 CU																		
43 PHS	60	60	50	60	70	30												
44 PHS	35	55	55	75	55	60												
45 PHS	95	75	85	70	70	75	75	50	60	75	70	85	70	40	60	65	40	35
46 CU																		
47 PHS		65	80	45	80	60												
48 FDA		63			66			56			42							
49 CU																		
50 PHS	45	50	50	50	40	40												
51 PHS	45	35	40	30	35	20												
52 FDA		30			26			19			21							
53 PHS	20	30	30	25	20	30	20	25	30	15	20	25	20	15	25	25	15	25
54 PHS	65	45	55	65	50	75												
55 PHS	35	45	40	85	35	65	55	30	35	45	40	25	30	20	10	30	30	20
56 FDA		33			40			39			26							
57 PHS	80	140	125	120	85	55	65	65	40	40	45	30	45	35	40	30	30	30
58 PHS	75	60	65	75	45	75												
59 CU																		
60 PHS	105	70	80	65	75	70	80	60	60	55	50	45	50	70	40	65	40	50
61 FDA		48						54			37							
62 PHS	30	45	40	60	60	55												
63 CU																		
64 PHS	40	40	40	55	35	45												
65 CAL		[d]27		[d]29		[d]32		[d]30		[d]22		[d]25		[d]18		[d]12		[d]15
66 CAL		[d]29		[d]22		[d]30		[d]33		[d]23		[d]21		[d]17		[d]18		[d]14
67 PHS				30	35	40												
68 FDA		39						33			22							
69 HASL			74			59			40			52						
70 CU																		
71 CAL		[d]31		[d]38		[d]30		[d]28		[d]32				[d]32		[d]13		[d]14
72 PHS	35	55	20	25	30	30	30	25	40	35	15	35	20	20	20	20	25	25
73 CU																		
74 CAL		[d]35		[d]30		[d]29		[d]22				[d]16		[d]17		[d]23		[d]15
75 CAL		[d]25		[d]29		[d]25		[d]26		[d]28		[d]13		[d]27		[d]13		[d]16
76 CAL		[d]29		[d]27		[d]30		[d]24		[d]24		[d]23		[d]19		[d]13		[d]11
77 PHS	75	100	80	45	60	30	35	15	50	40	35	25	25	35	25	20	20	30

See footnotes at end of table.

Table 2. Cesium-137 radioactivity in total diet samples—Continued (pCi/kg)

Program[a]	1966						1967											
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1 PHS	45	40	30	30	40	30	30	20	30	15	20	15		26	25			
2 PHS																32	25	26
3 CU																		
4 PHS	30		25	25	25	30	35	25	30	30	25	15	32		19	24	28	17
5 FDA																		
6 PHS																		
7 PHS																		
8 CONN	30	30	30	10	30	30	30	20		30	10	20	30		20	20		10
9 PHS																		
10 HASL																		
11 CU																		
12 PHS																		
13 PHS		25	25	25	25	25	15	25	20	10	15	30	17	14	[c]0	[c]0	12	14
14 PHS																		
15 FDA																		
16 PHS																		
17 CU																		
18 PHS	30	20	30	20	25	15	25	15	25	10	20	20	[c]0	12	[c]0	11	[c]0	11
19 PHS																		
20 PHS	20	20	15	25	25	20	25	20	25	20	10	10	16	[c]0	20	[c]0	24	18
21 PHS																		
22 PHS																		
23 PHS	20	15	20	25	25	25	15	20	20	10	15	15	22	18	11	15	15	24
24 HASL																		
25 CU																		
26 PHS																		
27 PHS			15	15	20	15	20	15	15	15	10	15	[c]0	14	[c]0	12	[c]0	[c]0
28 PHS																		
29 PHS	35	30	40	25	30	25	25	25	20	30	20	30	46	26	21	26	18	16
30 CU																		
31 PHS																		
32 FDA																		
33 PHS																		
34 PHS													18	20	20	18	19	[c]0
35 PHS	35	35	35	25	20	10	25	10	20	15	55	20	25	22	26	18	19	14
36 CU																		
37 PHS	20	15	20	15	15	10	20	15	20	20	15	20	15	17	23	14	[c]0	[c]0
38 CU																		
39 PHS																		
40 PHS					20	10	20	15	25	10	15	10					16	13
41 FDA																		
42 CU																		
43 PHS																		
44 PHS													11	[c]0	15	[c]0	16	[c]0
45 PHS	35				25	15	20	25	20	15	20	15	[c]0	[c]0	[c]0	14	15	15
46 CU																		
47 PHS																		
48 FDA																		
49 CU																		
50 PHS																		
51 PHS																		
52 FDA																		
53 PHS	15	15	10	15	5	15	15	5	10	10	5	15	[c]0	[c]0	[c]0	[c]0	[c]0	[c]0
54 PHS																		
55 PHS	20	25	20	15	5	10	25	5	15	15	15	25	15	13	11	19	13	14
56 FDA																		
57 PHS	25	35	30	30	30	20	30	25	10	10	20	15	12	26	[c]0	16	14	13
58 PHS													11	[c]0	11	12	[c]0	[c]0
59 CU																		
60 PHS	40		40	5	45	40	45	20	10	15	35	30	18	[c]0	20	20	12	22
61 FDA																		
62 PHS													17	21	20	19	31	12
63 CU																		
64 PHS													20	[c]0	17	17	15	[c]0
65 CAL		[d]16		[d]10		[d]6		[d]8		[d]7		[d]10		[d]2		[d]6		
66 CAL		[d]14		[d]16		[d]8		[d]16		[d]12		[d]7		[d]5		[d]6		
67 PHS													19	11	15	11	12	[c]0
68 FDA																		
69 HASL																		
70 CU																		
71 CAL		[d]11		[d]11		[d]9		[d]8		[d]5		[d]4		[d]6		[d]8		
72 PHS	25	20	25	25	30	20	15	20	10	15	10	10	[c]0	12	12	[c]0	[c]0	[c]0
73 CU																		
74 CAL		[d]11		[d]15		[d]15		[d]11		[d]7		[d]9		[d]8		[d]8		
75 CAL		[d]15		[d]12		[d]8		[d]13				[d]14		[d]5		[d]6		
76 CAL		[d]12		[d]11		[d]9		[d]7		[d]6		[d]6		[d]4		[d]5		
77 PHS	10	20	5	15	15	10	10	5	5	15	10	10	15	11	11	[c]0	15	

[a] Agency symbols identified in figure 1. See beginning of table for a breakdown of area by using the program code.
[b] The Consumers Union data from the Boston, Mass., station were not used because sufficient data pairs could not be formed for a valid comparison.
[c] Zero indicates a value less than the minimum detectable level of 10 pCi/kg.
[d] Bimonthly samples includes preceding month.

Table 3. Results of the sign test for paired observations applied to strontium-90 data[a]

Comparison	Number of data pairs	0.25 significance level	0.10 significance level	0.05 significance level
PHS (Portland, Maine)—PHS (Burlington)	15	−	+	[b] +
CU (Portland, Maine)—PHS (Boston)	6	−	+	+
PHS (Portland, Maine)—PHS (Boston)	18	−	−	−
PHS (Boston)—FDA (Boston)	6	−	+	+
PHS (Portland, Maine)—CONN (Hartford)	15	−	−	−
PHS (Portland, Maine)—PHS (Hartford)	12	−	−	−
CONN (Hartford)—PHS (Hartford)	12	−	−	−
PHS (Burlington)—PHS (Boston)	35	−	−	+
PHS (Burlington)—FDA (Boston)	5	+	+	0
PHS (Burlington)—CONN (Hartford)	34	+	+	+
PHS (Burlington)—PHS (Hartford)	11	−	−	−
FDA (Boston)—CONN (Hartford)	5	+	+	0
PHS (Boston)—CONN (Hartford)	46	+	+	+
PHS (Boston)—PHS (Hartford)	12	−	−	−
CU (Boston)—PHS (New York)	5	−	−	0
FDA (Boston)—HASL (New York)	5	−	−	0
PHS (Boston)—CU (New York)	15	+	+	+
PHS (Boston)—PHS (New York)	23	−	−	+
PHS (Boston)—HASL (New York)	18	+	+	+
CU (New York)—PHS (New York)	10	+	+	+
CU (New York)—HASL (New York)	5	+	+	0
PHS (New York)—HASL (New York)	10	+	+	+
PHS (Providence)—CONN (Hartford)	5	+	+	0
PHS (Providence)—PHS (Hartford)	5	+	+	0
CONN (Hartford)—CU (New York)	7	+	+	+
CONN (Hartford)—PHS (New York)	12	+	+	+
CONN (Hartford)—HASL (New York)	16	+	+	[b] +
PHS (Hartford)—PHS (New York)	6	−	+	+
CONN (Hartford)—PHS (Trenton)	11	−	−	[b] +
PHS (Hartford)—PHS (Trenton)	11	+	+	+
PHS (New York)—PHS (Trenton)	6	−	−	−
PHS (New York)—PHS (Wilmington)	6	+	+	+
HASL (New York)—PHS (Wilmington)	15	−	−	[b] −
PHS (New York)—PHS (Baltimore)	6	+	+	+
PHS (Trenton)—PHS (Wilmington)	10	+	+	+
PHS (Trenton)—PHS (Baltimore)	10	−	−	−
PHS (Wilmington)—PHS (Baltimore)	12	−	−	−
PHS (Wilmington)—FDA (Washington)	8	+	+	+
PHS (Baltimore)—PHS (Norfolk)	11	+	+	+
FDA (Washington)—PHS (Norfolk)	11	−	+	+
CU (Buffalo)—PHS (Cleveland)	9	+	+	+
PHS (Cleveland)—PHS (Pittsburgh)	41	−	−	−
PHS (Cleveland)—PHS (Detroit)	11	−	+	+
PHS (Pittsburgh)—PHS (Charleston, W.Va.)	12	−	−	−
PHS (Charlotte)—PHS (Charleston, S.C.)	11	+	+	+
PHS (Atlanta)—CU (Knoxville)	14	−	−	−
FDA (Atlanta)—CU (Knoxville)	5	+	+	0
PHS (Atlanta)—FDA (Atlanta)	11	+	+	+
PHS (Atlanta)—PHS (Montgomery)	13	−	−	−
PHS (New Orleans)—PHS (Columbia)	23	−	−	−
CU (New Orleans)—PHS (New Orleans)	14	+	+	+
PHS (Louisville)—PHS (Indianapolis)	12	−	−	−
PHS (Indianapolis)—PHS (Chicago)	12	+	+	+
CU (Chicago)—PHS (Chicago)	10	−	−	−
PHS (Chicago)—HASL (Chicago)	18	+	+	+
PHS (Memphis)—CU (Little Rock)	10	−	+	+
PHS (Memphis)—PHS (Little Rock)	15	−	−	−
PHS (Chicago)—PHS (Milwaukee)	13	−	−	+
PHS (St. Louis)—CU (St. Louis)	7	−	+	+
PHS (St. Louis)—FDA (St. Louis)	14	−	+	+
CU (Duluth)—PHS (Minneapolis)	6	+	+	+
PHS (Minneapolis)—FDA (Minneapolis)	12	+	+	+
PHS (Dex Moines)—PHS (Omaha)	13	+	+	[b] +
CU (Sioux Falls)—PHS (Omaha)	11	+	+	+
PHS (Sioux Falls)—PHS (Omaha)	11	−	+	+
PHS (Wichita)—PHS (Oklahoma City)	12	+	+	+
PHS (Laramie)—PHS (Denver)	15	+	+	+
PHS (Laramie)—FDA (Denver)	5	−	−	0
PHS (Denver)—FDA (Denver)	10	+	+	+
PHS (Idaho Falls)—PHS (Salt Lake City)	17	−	−	−

See footnotes at end of table.

Table 3. Results of the sign test for paired observations applied to strontium-90 data[a]—Continued

Comparison	Number of data pairs	0.25 significance level	0.10 significance level	0.05 significance level
PHS (Seattle)—FDA (Seattle)	11	−	−	−
PHS (Seattle)—CU (Portland, Ore.)	13	+	+	+
PHS (Seattle)—PHS (Portland, Ore.)	17	−	−	−
PHS (Carson City)—CAL (Sacramento)	7	−	−	−
PHS (Carson City)—CAL (Berkeley)	7	−	−	−
CAL (Sacramento)—CAL (Berkeley)	19	+	+	+
PHS (Carson City)—HASL (San Francisco)	6	−	−	−
PHS (San Francisco)—PHS (Carson City)	8	+	+	+
CAL (Sacramento)—HASL (San Francisco)	8	+	+	+
CAL (Sacramento)—FDA (San Francisco)	9	+	+	+
CAL (Berkeley)—HASL (San Francisco)	10	+	+	+
CAL (Berkeley)—FDA (San Francisco)	8	+	+	+
HASL (San Francisco)—FDA (San Francisco)	14	+	+	+
PHS (Los Angeles)—CAL (San Diego)	19	−	−	−
CAL (Los Angeles)—CAL (San Diego)	13	+	+	+
PHS (Los Angeles)—CAL (Santa Barbara)	18	−	−	−
CAL (Los Angeles)—CAL (Santa Barbara)	19	+	+	+
CU (Los Angeles)—PHS (Los Angeles)	8	+	+	+
PHS (Los Angeles)—CAL (Los Angeles)	21	−	−	−
CAL (Needles)—PHS (Phoenix)	17	−	−	−
PHS (Oklahoma City)—FDA (Dallas)	5	+	+	0
FDA (Dallas)—PHS (Austin)	8	+	+	+

[a] + indicates measurements agree at the significance level given. − indicates disagreement. 0 indicates number of data pairs is insufficient to allow application of statistical test.

[b] The Wilcoxon signed-ranks test indicates these data pairs disagree at the 0.05 significance level.

about 75 percent of the comparisons agree where sites are 0–100 miles apart and less than 60 percent agree for cities at 100–200 miles distant. Although the specific location from which the samples for a given geographical area were collected is uncertain, the inference from the results suggest actual differences in the radioactive content of the samples rather than analytical divergences of data. However, whether the results are grouped by agency for separate cities or by city for different agencies, there is little differences in the degree of concordance.

The results of the comparative study are summarized in table 5. The overall agreement (at a significance level equal to 0.05) between the various agencies is about 60 percent for the radionuclides considered in total diet samples collected at about the same place and time. Although the USDA survey (*4*) showed that teenagers have the greatest variety in their diet, our study indicates that the amount of strontium-90 reported in the HASL and CAL general population diets is in agreement with the PHS, FDA, CU, and CONN values in 8 of 16 comparisons.

Conclusions

In consideration of the statistical limitations of the data included in this study and the very low levels of the radioactivities, the values reported by any one of the participating agencies may be accepted with equal reliability.

Four of the six programs reviewed report radioactivity in the diets of children and of teenage groups. Practical consideration of the situation at these low activities indicates there is very little difference between the values reported for diets of these special age groups and those reported for the diet of the general population.

Acknowledgment

The authors gratefully acknowledge the help of Miss Janet Springer in the statistical analysis of the data.

REFERENCES

(*1*) U.S. FOOD AND DRUG ADMINISTRATION. Teen-age diet survey, May 1961–August 1962. Radiol Health Data 4:18–22 (January 1963).

(*2*) U.S. ATOMIC ENERGY COMMISSION, HEALTH AND SAFETY LABORATORY. Tri-City diet study. Radiol Health Data 2:181–184 (April 1961).

(*3*) U.S. PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Institutional Diet Sampling Program. Radiol Health Data 3:42–45 (February 1962).

(*4*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (1955).

(*5*) CALIFORNIA STATE DEPARTMENT OF PUBLIC HEALTH. Estimated daily intake of radionuclides in California diets, January–June 1964. Radiol Health Data 6:153–154 (March 1965).

Table 4. Results of sign test for paired observations applied to cesium-137 data[a]

Comparison	Number of data pairs	0.25 significance level	0.10 significance level	0.05 significance level
PHS (Burlington)—PHS (Portland, Maine)	15	−	+	[b] +
PHS (Burlington)—PHS (Boston)	35	+	+	+
PHS (Burlington)—FDA (Boston)	7	+	+	+
PHS (Burlington)—PHS (Hartford)	9	−	+	+
PHS (Burlington)—CONN (Hartford)	34	+	+	+
PHS (Portland, Maine)—PHS (Boston)	17	+	+	+
PHS (Portland, Maine)—FDA (Boston)	5	−	−	0
PHS (Portland, Maine)—PHS (Hartford)	12	−	−	−
PHS (Portland, Maine)—CONN (Hartford)	16	−	−	[b] +
CU (Portland, Maine)—PHS (Boston)	6	+	+	+
PHS (Boston)—FDA (Boston)	9	+	+	[b] +
PHS (Boston)—PHS (Providence)	5	+	+	0
PHS (Boston)—PHS (Hartford)	12	−	−	−
PHS (Boston)—CONN (Hartford)	48	−	−	[b] +
PHS (Boston)—PHS (New York)	24	−	−	−
PHS (Boston)—HASL (New York)	5	+	+	0
PHS (Boston)—CU (New York)	16	−	−	[b] +
FDA (Boston)—CONN (Hartford)	9	+	+	+
PHS (Providence)—CONN (Hartford)	5	+	+	0
PHS (Hartford)—CONN (Hartford)	12	+	+	+
PHS (Hartford)—PHS (New York)	5	−	−	0
PHS (Hartford)—PHS (Trenton)	9	−	+	[b] +
CONN (Hartford)—PHS (New York)	14	−	+	[b] +
CONN (Hartford)—CU (New York)	8	+	+	+
CONN (Hartford)—PHS (Trenton)	11	−	−	−
PHS (New York)—CU (New York)	11	+	+	+
PHS (New York)—PHS (Trenton)	6	−	+	+
PHS (New York)—PHS (Wilmington)	8	+	+	+
PHS (New York)—PHS (Baltimore)	6	−	−	−
PHS (Trenton)—PHS (Wilmington)	9	−	+	[b] +
PHS (Trenton)—PHS (Baltimore)	9	−	+	+
PHS (Wilmington)—PHS (Baltimore)	13	−	−	−
PHS (Wilmington)—FDA (Washington)	5	+	+	0
PHS (Baltimore)—PHS (Norfolk)	13	+	+	+
FDA (Washington)—PHS (Norfolk)	12	−	−	−
CU (Buffalo)—PHS (Cleveland)	10	+	+	+
PHS (Cleveland)—PHS (Detroit)	11	+	+	+
PHS (Cleveland)—PHS (Pittsburgh)	37	+	+	+
PHS (Pittsburgh)—PHS (Charleston, W.Va.)	11	−	−	−
PHS (Milwaukee)—PHS (Chicago)	9	+	+	+
PHS (Chicago)—HASL (Chicago)	5	+	+	0
PHS (Chicago)—CU (Chicago)	10	+	+	+
PHS (Chicago)—PHS (Indianapolis)	13	−	−	−
PHS (Indianapolis)—PHS (Louisville)	13	−	−	−
PHS (Charlotte)—PHS (Charleston, S.C.)	12	−	−	−
CU (Knoxville)—PHS (Atlanta)	15	−	+	+
CU (Knoxville)—FDA (Atlanta)	6	+	+	+
PHS (Atlanta)—FDA (Atlanta)	12	+	+	+
PHS (Atlanta)—PHS (Montgomery)	12	−	−	−
PHS (Columbia)—PHS (New Orleans)	21	−	−	[b] +
PHS (New Orleans)—CU (New Orleans	15	+	+	+
PHS (Little Rock)—PHS (Memphis)	14	−	−	[b] +
CU (Little Rock)—PHS (Memphis)	10	−	−	−
PHS (St. Louis)—FDA (St. Louis)	9	+	+	+
PHS (St. Louis)—CU (St. Louis)	6	+	+	+
PHS (Des Moines)—PHS (Omaha)	12	+	+	+
PHS (Omaha)—PHS (Sioux Falls)	12	+	+	[b] +
PHS (Omaha)—CU (Sioux Falls)	10	−	+	+
PHS (Minneapolis)—FDA (Minneapolis)	12	+	+	+
PHS (Minneapolis)—CU (Duluth)	9	−	+	+
PHS (Wichita)—PHS (Oklahoma City)	11	+	+	+
PHS (Oklahoma City)—FDA (Dallas)	5	+	+	0
FDA (Dallas)—PHS (Austin)	9	−	+	+
PHS (Laramie)—PHS (Denver)	14	−	−	+
PHS (Laramie)—FDA (Denver)	5	+	+	0
PHS (Denver)—FDA (Denver)	10	+	+	+
PHS (Idaho Falls)—PHS (Salt Lake City)	17	−	−	−
CU (Salt Lake City)—PHS (Salt Lake City)	6	+	+	+
PHS (Seattle)—FDA (Seattle)	10	+	+	+
PHS (Seattle)—PHS (Portland, Ore.)	17	−	−	−

See footnotes at end of table.

Table 4. Results of sign test for paired observations applied to cesium-137 data[a]—Continued

Comparison	Number of data pairs	0.25 significance level	0.10 significance level	0.05 significance level
PHS (Seattle)—CU (Portland, Ore.)	14	−	+	+
PHS (Carson City)—CAL (Sacramento)	7	−	−	−
PHS (Carson City)—CAL (Berkeley)	7	−	−	−
PHS (Carson City)—PHS (San Francisco)	7	−	+	+
CAL (Sacramento)—CAL (Berkeley)	21	+	+	+
CAL (Sacramento)—FDA (San Francisco)	7	−	+	[b] +
CAL (Berkeley)—FDA (San Francisco)	6	−	−	−
FDA (San Francisco)—HASL (San Francisco)	5	−	−	0
CAL (Santa Barbara)—PHS (Los Angeles)	15	−	+	+
CAL (Santa Barbara)—CAL (Los Angeles)	16	+	+	+
PHS (Los Angeles)—CU (Los Angeles)	11	+	+	+
PHS (Los Angeles)—CAL (Los Angeles)	19	−	−	[b] +
PHS (Los Angeles)—CAL (San Diego)	19	−	−	−
CAL (Los Angeles)—CAL (San Diego)	20	+	+	+
CAL (Needles)—PHS (Phoenix)	17	−	−	−

[a] + indicates measurements agree at the significance level given. − indicates disagreement. 0 indicates number of data pairs is insufficient to allow application of statistical test.
[b] The Wilcoxon signed-ranks test indicates these data pairs disagree at the 0.05 significance level.

Table 5. Summary of results of statistical tests shown in tables 3 and 4[a]

	Sign test			Signed-ranks test
	$\alpha = 0.25$	$\alpha = 0.10$	$\alpha = 0.05$	$\alpha = 0.05$
Strontium-90 data:				
Total number of sets of data pairs	92	92	82	82
Number of cases where test indicates data do not differ, on the average	47 (51%)	57 (62%)	54 (66%)	51 (62%)
Cesium-137 data:				
Total number of sets of data pairs	85	85	75	75
Number of cases where test indicates data do not differ, on the average	40 (47%)	55 (65%)	55 (73%)	42 (56%)

[a] α = significance level of test.

REFERENCES—Continued

(6) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet, March 1963–December 1964. Radiol Health Data 6:381–382 (July 1965).

(7) CONSUMERS' UNION. Selected results from total diet studies, May 1961–June 1962. Radiol Health Data 4:353–358 (July 1963).

(8) U.S. FOOD AND DRUG ADMINISTRATION. Radionuclides in diets for teen-agers. Radiol Health Data 4:285–286 (June 1963); 5:181–183 (April 1964); 6:378–380 (July 1965); 7:459–461 (August 1966).

(9) U.S. ATOMIC ENERGY COMMISSION. Health and Safety Laboratory Manual of Standard Procedures, AEC Report NYO-4700:E-38-01. New York Operations Office (1957).

(10) U.S. PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional diet samples. Radiol Health Data 3:224–242 (July 1962); 3:471–476 (December 1962); 4:177–182 (April 1963); 4:347–352 (July 1963); 4:441–446 (September 1963); 4:605–610 (December 1963); 5:131–136 (March 1964); 5:329–334 (July 1964); 5:485–491 (October 1964); 6:31–36 (January 1965); 6:216–222 (April 1965); 6:371–377 (July 1965); 6:548–554 (October 1965); 7:92–98 (February 1966); 7:288–292 (May 1966); 7:398–403 (July 1966); 7:580–583 (October 1966); 8:15–18 (January 1967); 8:209–212 (April 1967); 8:388–391 (July 1967); 8:591–596 (October 1967); 9:34–36 (January 1968); 9:217–220 (April 1968); and 9:359–363 (July 1968).

(11) BARATTA, E. J. and E. R. WILLIAMS. Radionuclide levels in teen-age diets—a comparative study of two sampling programs, February–June 1964. Radiol Health Data 6:37–40 (January 1965).

(12) CONSUMERS' UNION. Selected results from total diet studies, February 1963–June 1964. Radiol Health Data 6:700–703 (December 1965).

(13) U.S. ATOMIC ENERGY COMMISSION, HEALTH AND SAFETY LABORATORY. Tri-City diet study. Radiol Health Data 2:435–436 (October 1961); 2:519 (December 1961); 3:82–83 (March 1962); 3:183–185 (June 1962); 3:334–335 (September 1962); 4:13–14 (January 1963); 4:130–131 (March 1963); 4:289–290 (June 1963); 4:446–448 (September 1963); 4:611–612 (December 1963); 5:137–138 (March 1964); 5:285–288 (June 1964); 5:288–290 (June 1964); 5:433–434 (September 1964); 5:434–436 (September 1964); 5:603–604 (December 1964); 6:151–152 (March 1965); 6:323–324 (June 1965); 6:503–506 (September 1965); 6:704–705 (December 1965); 7:170–171 (March 1966); 7:349–350 (June 1966); 7:506–507 (September 1966); 7:713–714 (December 1966); 8:154–157 (March 1967); 8:329–330 (June 1967); 8:517–518 (September 1967); 9:166–167 (March 1968); 9:302-304 (June 1968).

(14) CALIFORNIA STATE DEPARTMENT OF PUBLIC HEALTH. Estimated daily intake of radionuclides in California diets. Radiol Health Data 6:501–502 (September 1965); 7:172–173 (March 1966); 7:351–352 (June 1966); 7:508–511 (September 1966); 8:19–21 (January 1967); 8:271–274 (May 1967); 8:596–599 (October 1967); 9:102–104 (February 1968); 9:261–263 (May 1968).

(15) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet. Radiol Health Data Rep 7:99 (February 1966); 7:645–646 (November 1966); 8:274–275 (May 1967); 8:646–647 (November 1967); 9:264 (May 1968).

(16) NATRELLA, M. G. Experimental statistics, NBS Handbook 91. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (August 1963).

Technical Notes

Environmental Levels of Radioactivity in Utah Following Operation Pinstripe[1]

R. C. Pendleton and *R. D. Lloyd*[2]

Following the announcement by the U.S. Atomic Energy Commission that the underground nuclear detonation of April 25, 1966, had vented (external gamma) radioactivity surveillance was carried out and a series of samples of green vegetation were collected on April 29 and 30, 1966. The green samples were chosen because they would not contain much residual radioactivity from previous shots since the growing time, at the most, for these specimens was 2 weeks. This surveillance and sampling was designed to show the location in our sampling network where fresh fission elements from this venting had fallen.

The samples were counted 3 days after collection using an 8- by 4-inch NaI (T1) crystal and a 400-channel pulse-height analyser. The concentrations of the various gamma-ray emitting radionuclides present in these samples were calculated by the IBM 7044 computer at the University of Utah Computer Center using the Polyspec program (*1*). Increased levels of iodine-131 and zirconium-95 were detected in all of the samples collected at that time. Figure 1 shows the gamma-ray spectrum of one of these samples, and table 1 lists the concentrations of radionuclides in several samples.

After a delay of more than 2 months when the iodine-131 activity had virtually disappeared because of radioactive decay, the samples were recounted. After an additional delay of more than 4 months (>6 months total) when any ruthenium-103 originally present would have decayed to less than 4 percent of the initial activity, the samples were again recounted.

[1] This investigation was supported by U.S. Public Health Service Research Grant RH-00030, Bureau of Radiological Health.

[2] University of Utah, Salt Lake City, Utah.

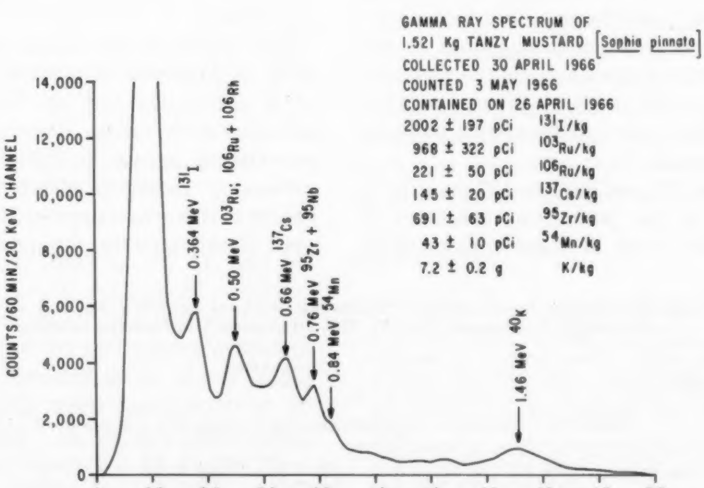

Figure 1. Spectrum of radionuclides in an annual spring plant

Table 1. Radionuclides in early spring vegetation collected following Operation Pinstripe

Station and sample number	Date (1966)	Concentration[a] (pCi/kg)						Potassium[b] (g/kg)
		Iodine–131	Ruthenium–103	Ruthenium–106	Cesium–137	Zirconium–95	Manganese–54	
40–139[c]	4/29	530 ± 45	257 ± 86	ND	340 ± 30	88 ± 21	ND	6.6 ± 0.4
41–132	4/29	883 ± 85	382 ± 107	177 ± 50	118 ± 10	268 ± 21	ND	9.4 ± .2
50–98[c]	4/30	1,107 ± 113	340 ± 96	407 ± 80	199 ± 40	291 ± 31	110 ± 20	9.6 ± .4
50–99[c]	4/30	2,002 ± 197	968 ± 322	221 ± 50	145 ± 20	691 ± 63	43 ± 10	7.2 ± .2
50–100[c d]	4/30	690 ± 70	282 ± 86	249 ± 50	213 ± 16	132 ± 16	56 ± 15	8.6 ± .3

[a] Standard errors represent counting statistics only. Antimony–125 in all samples was below limit of detection.
[b] Potassium determined by the analysis for potassium–40.
[c] Tanzymustard (*Sophia pinnata*).
[d] Kentucky bluegrass (*Poa prapensis*).
ND, nondetectable.

Since 40-day, half-life ruthenium–103 exhibits a gamma-ray peak at about 0.5 MeV and 365-day, half-life ruthenium–106 also has a 0.5 MeV gamma-ray associated with its decay chain, identification of both of these isotopes in a sample by recording a single spectrum is difficult. However, if two or more spectra are recorded sufficiently separated in time so that the ruthenium–103 undergoes considerable radioactive decay, appropriate analysis can separate the relative contribution of each to the observed 0.5 MeV peak.

The amount of ruthenium–106 in each sample at the 6-month count was corrected for radioactive decay back to each of the other counting dates. The counting rate corresponding to these values was then subtracted from the totals. The residual peak at 0.5 MeV was due to ruthenium–103. The ruthenium–103 activities could then be calculated based on its 40-day half-life and published decay scheme (*2*). Counting efficiencies (counts in the photopeak) per emitted gamma-ray for ruthenium–103 and ruthenium–106 at 0.5 MeV were assumed to be identical. This analytical technique was also reported in reference 3.

Although iodine–131 and cesium–137 make up a large percentage of the gamma-ray spectrum of these samples, the levels of these radionuclides normalized relative to the other fission products present do not show isotopic fractionation in favor of elements having gaseous precursors as advanced by Martell relative to underground nuclear detonations (*4*).

In contrast to the obviously fresh fission spectrum found in the samples taken April 30 in the main fallout track, samples of desert shrubs taken on April 23 showed a spectrum characteristic of old fallout (table 2). These levels reflect several years of contamination accumulation.

No significant increases in iodine–131, cesium–137 or strontium–90 were detected in milk as a result of this venting. Because the dairy cattle in the selected sampling array that were within the reported fallout tract were not grazing during this period of time, only small quantities of fresh fission products would be expected to appear in the milk.

The width of the fallout track was surveyed using a Precision Radiation Instrument Model 111B scintillator and an Eberline E–510 beta-gamma survey meter. Results of our background surveillance appear in table 3. Only slight elevations of radiation above normal background (which in this area is approximately 0.02 mR/hour) were found outside the probable fallout path,

Table 2. Levels of radionuclides in desert shrubs (Shadscale, *Atriplex confertifolia* and Greasewood, *Sarcobatus vermiculatus*) collected April 23, 1966 (just prior to Pinstripe venting)

Station and sample number	Concentration[a] (pCi/kg)						Potassium[b] (g/kg)
	Iodine–131	Antimony–125	Ruthenium–106	Cesium–137	Zirconium–95	Manganese–54	
211–1–2	<32	336 ± 50	156 ± 50	461 ± 40	<14	89 ± 20	8.3 ± 0.2
211–1–3	<29	221 ± 50	222 ± 50	326 ± 30	<13	96 ± 20	12.6 ± .2
211–1–6	<18	823 ± 80	391 ± 40	1,193 ± 60	< 9	213 ± 20	7.4 ± .2
211–1–7	<34	1,034 ± 100	732 ± 70	1,426 ± 70	<17	335 ± 30	10.4 ± .2
211–1–9	<38	151 ± 30	ND	131 ± 13	<19	ND	7.1 ± .1

[a] Standard errors represent counting statistics only.
[b] Potassium determined by the analysis for potassium–40.
ND, nondetectable.

Table 3. Background radiation levels following Operation Pinstripe

Sampling location	Radiation level[a] (mR/hr)
Station 34, Chester, Sanpete Country	[b]0.029 ± .0058 [c].035 ± .0035
Station 33, Ephraim, Sanpete County	.030 ± .0042 .042 ± .0030
Manti, Sanpete County	.024 ± .0029 .026 ± .0029
Gunnison, Sanpete County	.029 ± .0033 .033 ± .0034
Station 66, Axtell, Sevier County	.030 ± .0042 .036 ± .0029
Salina, Sevier County	.019 ± .0024 .024 ± .0010
Richfield, Sevier County	.021 ± .0033 .022 ± .0037
Station 40, Monroe, Sevier County	.028 ± .0034 .045 ± .0065
Summit between Cove Fort and Monroe, Millard County	.038 ± .0051 .036 ± .0043
Station 41, Beaver, Beaver County	.026 ± .0029 .039 ± .0029
Station 50, Beaver, Beaver Country	.050 ± .0052 .056 ± .0062
Station 43, Parowan, Iron County	.022 ± .0034 .033 ± .0020
Cedar City (City Park), Iron County	.028 ± .0025 .028 ± .0020
Kanarraville, Iron County	.022 ± .0075 .044 ± .0058
Station 46, Midvalley Road, 4 miles NW of Cedar City, Iron County	.027 ± .0012 .032 ± .0046
Minersville, Beaver County	.028 ± .0020 .035 ± .0042
Milford, Beaver County	.027 ± .0060 .053 ± .0044
Ranch Exit, Interstate 15, Beaver County	.039 ± .0064 .053 ± .0044
Cove Fort, Millard County	.038 ± .0046 .040 ± .0027
Station 54, Ferron, Emery County	.025 ± .0022 .042 ± .0066
Summit between Willow Creek, Carbon County and Indian Canyon, Duchesne County	.035 ± .0034 .046 ± .0036
Station 64, Wellington, Carbon County	.024 ± .0019 .032 ± .0041
Price, Carbon County	.031 ± .0037 .035 ± .0045
Bamberger Monument, Monument Park, Carbon County	.026 ± .0033 .052 ± .0034
Indian Canyon (5 miles NE of summit) Duchesne County	.030 ± .0035 .052 ± .0098
Current Creek Lodge, Wasatch County	.024 ± .0019 .032 ± .0020
Station 58, Duchesne County	[d].020 .022

[a] Each measurement represents the mean of 5 or more readings at 15 seconds intervals, ± values are standard errors.
[b] One meter above ground surface—gamma radiation readings only.
[c] Ground surface beta plus gamma radiation readings.
[d] Standard error not available.

which centered around stations 40, 41, and 50 (figure 2). However, elevation of the radioactivity level above background by a factor of 2 was noted at several locations. Had the surveillance extended into northern Utah, elevated levels above background would probably have been detected in stations 1, 2, 3, 4, and 5 in the Salt Lake Valley and stations in Summit County 9, 10, 31, and 32—10.3 pCi gross beta radioactivity per cubic meter[3] of air was reported at Provo on April 26, 1966 by the Utah State Radiological Surveillance Network, (*5*). Our surveillance was conducted primarily in the south and east section of our sampling array because first reports of increased airborne radioactivity, released by the Utah State Department of Health, showed an elevation (16.2 pCi/m^3) only at Richfield, which is within 10 miles of our station No. 40. However, our measurements indicated that the levels of radiation at Richfield were not above normal background radiation.

[3] The average gross beta radioactivity for Provo for the period, March 1–April 25, was 0.6 pCi/m^3 with a maximum of 2.8 pCi/m^3 occurring on March 21.

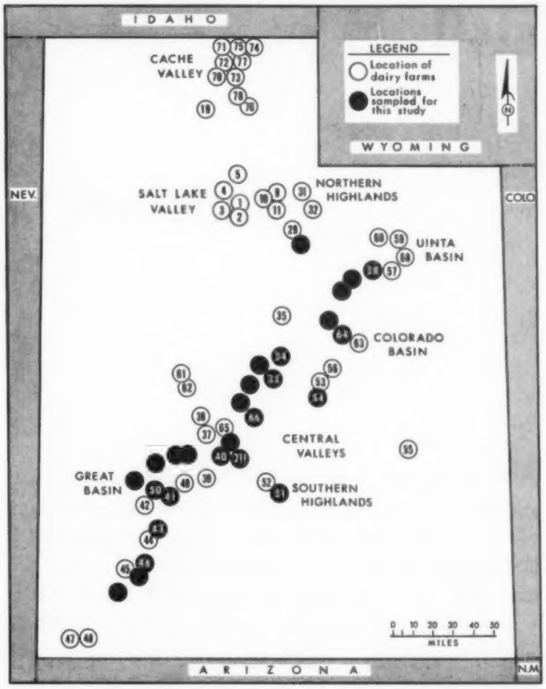

Figure 2. Sampling locations of diary farms

REFERENCES

(*1*) LLOYD, R. D., J. A. CHRISTENSEN, B. W. CHURCH, P. S. FISHER, C. W. MAYS, and R. C. PENDLETON. Polyspec: a computer program to resolve complex gamma-ray spectra from samples of different densities. Health Physics 13:851–855 (1967).

(*2*) STROMINGER, D., J. HOLLANDER, and G. T. SEABORG. Table of Isotopes. Rev Mod Physics 30:358 (1958).

(*3*) CHURCH, B. W., R. D. LLOYD, R. C. PENDLETON, and C. W. MAYS. Evidence for radio-ruthenium in milk. Nature 207:775 (1965).

(*4*) MARTELL, E. A. Iodine-131 fallout from underground tests. Science 143:126–129 (1964).

(*5*) DALLEY, D. R. Monthly Radiological Surveillance Reports—January 1966 to September 1966. Utah State Department of Health, Division of Sanitation (1966).

Data

SECTION I. MILK AND FOOD

Milk Surveillance, October 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network, (PMN) sponsored by the Bureau of Radiological Health, and the Bureau of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*: Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium–89, strontium–90, iodine–131, cesium–137, and barium–140. A sixth radionuclide, potassium–40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium–40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured

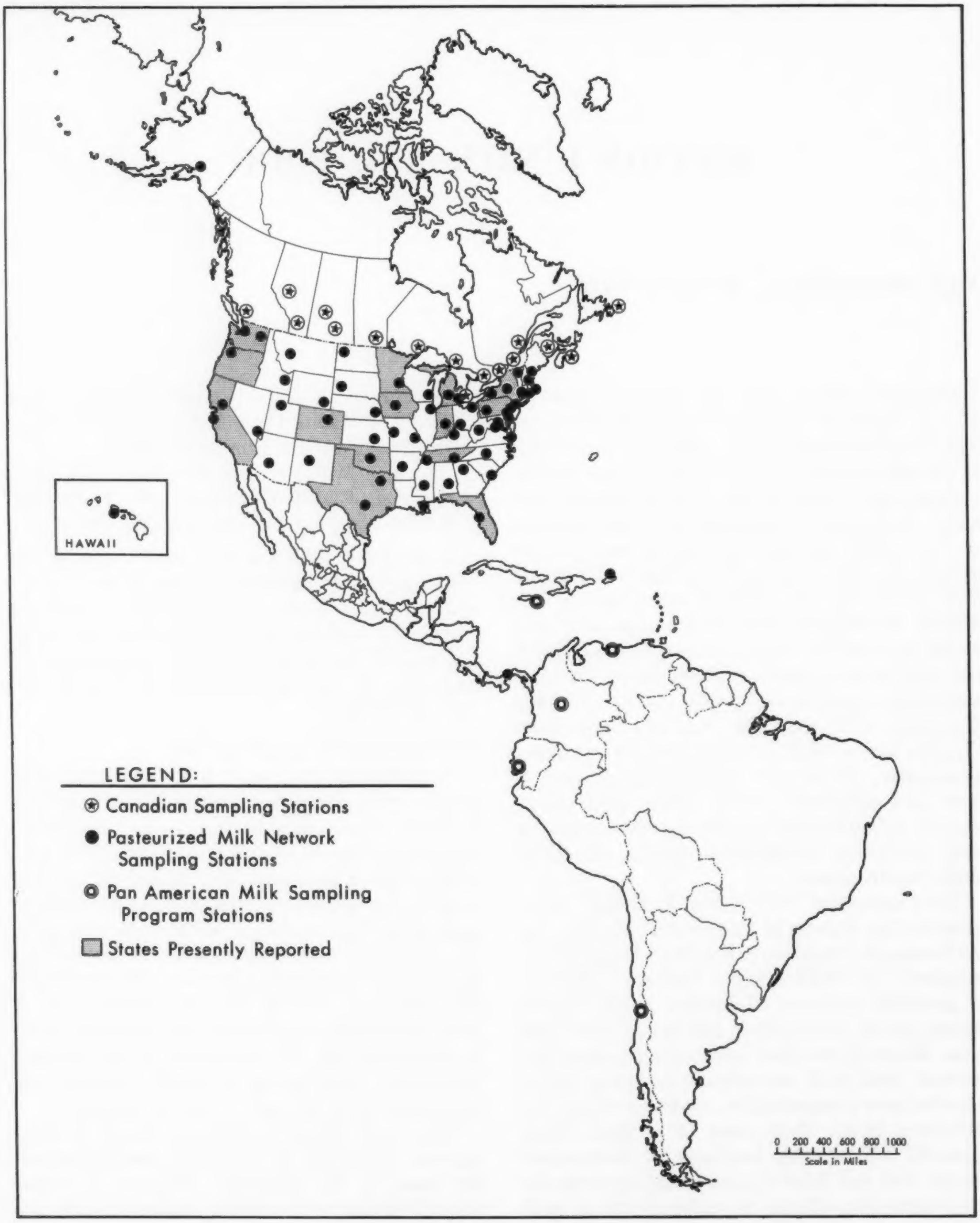

Figure 1. Milk sampling networks in the Western Hemisphere

extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in the period July–September 1969, with 31 laboratories participating in an experiment on milk samples containing known concentrations of strontium–90, iodine–131, cesium–137 and barium–140. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 15 participated in the experiment.

The iodine–131 and cesium–137 results show much improvement over previous tests. Barium–140 results also look good which is encouraging, since this is the first time barium–140 was analyzed for this type of experiment. However, strontium–89 and strontium–90 analysis still need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium–40, iodine–131, cesium–137, and barium–140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium–90 and cesium–137 are relatively stable over short time periods and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine–131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium–90 and cesium–137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurement equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥ 100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environment conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guides (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	RPG (rad/yr)	Guidance for suitable samples of exposed population group[a]			
				Corresponding continuous daily intake (pCi/day)	Range I[b] (pCi/day)	Range II[b] (pCi/day)	Range III[b] (pCi/day)
Strontium-89	Bone	[c] 1.5	0.5	[d] 2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	[c] .5	.17				
Strontium-90	Bone	[c] 1.5	.5	[d] 200	0–20	20–200	200–2,000
	Bone marrow	[c] .5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age: cesium-137—infants.
[b] Based on an average intake of 1 liter of milk per day.
[c] A dose of 1.5 rad/yr to the bone is estimated to result in a dose of 0.5 rad/yr to the bone marrow.
[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.
[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guides (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.
[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.
[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.
[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

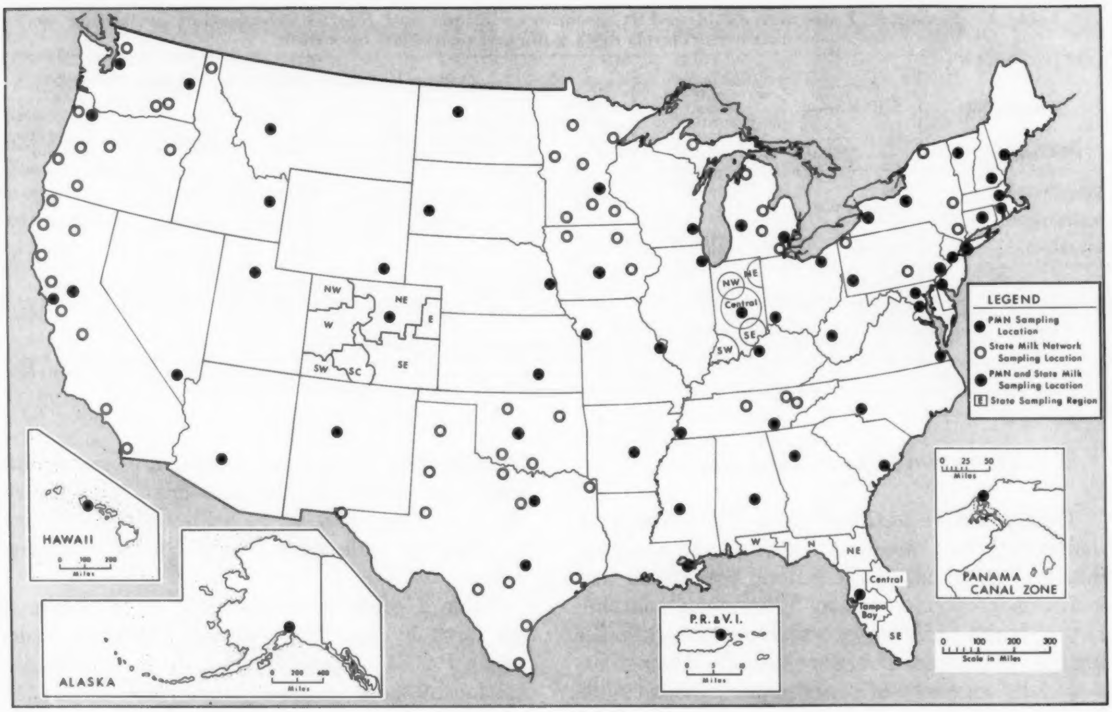

Figure 2. State and PMN milk sampling locations in the United States

and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2). The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131 and cesium-137 for October 1969 and the 12-month period, November

Table 3. Concentrations of radionuclides in milk for October 1969 and 12-month period, November 1968 through October 1969

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	11	7	0(5)	0	10(5)	10
Alaska:	Palmer[c]	P	4	6	0(4)	0	0(4)	6
Ariz:	Phoenix[c]	P	0	1	0(5)	0	0(5)	0
Ark:	Little Rock[c]	P	12	18	0(4)	0	16(4)	17
Calif:	Sacramento[c]	P	0	1	0(5)	0	0(5)	0
	San Francisco[c]	P	0	2	0(5)	0	0(5)	0
	Del Norte	P	22	19	0(4)	0	14(4)	14
	Fresno	P	0	0	0	0	0	1
	Humboldt	P	3	5	0(6)	0	0(6)	6
	Los Angeles	P	0	0	0	0	0	0
	Mendocino	P	4	3	0	0	0	1
	Sacramento	P	0	2	0	0	0	1
	San Diego	P	0	0	0	0	0	1
	Santa Clara	P	0	0	0	0	0	2
	Shasta	P	3	3	0	0	0	3
	Sonoma	P	0	2	0	0	0	0
Colo:	Denver[c]	P	5	5	0(5)	0	5(5)	2
	West	R	(d)		(e)	(e)	(e)	(e)
	Northeast	R	(d)		(e) (3)	(e)	(e) (3)	(e)
	East	R	(d)		NS	(e)	NS	(e)
	Southeast	R	(d)		(e)	(e)	(e)	(e)
	South central	R	(d)		NS	(e)	NS	(e)
	Southwest	R	(d)		(e) (2)	(e)	(e) (2)	(e)
	Northwest	R	(d)		(e)	(e)	(e)	(e)
Conn:	Hartford[c]	P	6	8	0(5)	0	9(5)	12
	Central	P	6	7	0(5)	0	12(5)	11
Del:	Wilmington[c]	P	9	9	0(5)	0	3(5)	7
D.C.:	Washington[c]	P	7	8	0(5)	0	3(5)	4
Fla:	Tampa[c]	P	5	7	0(5)	0	55(5)	58
	West	R	14	11	0	0	52	25
	North	R	18	14	0	0	38	30
	Northeast	R	5	8	0	0	73	65
	Central	R	7	7	0	1	72	56
	Tampa Bay area	R	9	8	0	0	70	62
	Southeast	R	6	8	0	0	93	93
Ga:	Atlanta[c]	P	11	10	0(5)	0	20(5)	19
Hawaii:	Honolulu[c]	P	2(4)	3	0(4)	0	0(4)	0
Idaho:	Idaho Falls[c]	P	5	5	0(4)	0	0(4)	6
Ill:	Chicago[c]	P	9	8	0(4)	0	8(4)	10
Ind:	Indianapolis[c]	P	6	8	0(4)	0	2(4)	6
	Northeast	P	8	12	0	0	10	10
	Southeast	P	10	8	0	0	10	10
	Central	P	8	10	0	0	10	10
	Southwest	P	8	10	0	0	20	10
	Northwest	P	10	10	0	0	20	20
Iowa:	Des Moines[c]	P	5	5	0(5)	0	0(5)	2
	Iowa City	P	NS		NS		NS	
	Des Moines	P	NS		NS		NS	
	Spencer	P	NS		NS		NS	
	Charles City	P	NS		NS		NS	
Kans:	Wichita[c]	P	6	7	0(4)	0	3(4)	2
Ky:	Louisville[c]	P	10	9	0(4)	0	2(4)	5
La:	New Orleans[c]	P	14	17	0(5)	0	19(5)	19
Maine:	Portland[c]	P	9	12	0(5)	1	16(5)	24
Md:	Baltimore[c]	P	11	9	0(4)	0	6(4)	7
Mass:	Boston[c]	P	11	11	0(4)	0	21(4)	21
Mich:	Detroit[c]	P	6	8	0(4)	0	10(4)	9
	Grand Rapids	P	6	10	0(4)	4	13(4)	14
	Bay City	P	7	7	(e) (8)	(e)	7	10
	Charlevoix	P	8	9	(e) (4)	(e)	15	16
	Detroit	P	7	5	(e) (4)	(e)	6	6
	Grand Rapids	P	6	8	(e) (4)	(e)	6	11
	Lansing	P	6	6	(e) (2)	(e)	14	10
	Marquette	P	9	10	(e) (2)	(e)	19	28
	Monroe	P	6	4	(e) (2)	(e)	0	1
	South Haven	P	NS	7	NS	(e)	NS	8
Minn:	Minneapolis[c]	P	12	10	0(4)	0	2(4)	11
	Bemidji	P	21	17	0	0	36	25
	Mankato	P	9	8	0	0	12	0
	Rochester	P	9	9	0	0	0	0
	Duluth	P	18	19	0	0	24	25
	Worthington	P	7	8	0	0	0	0
	Minneapolis	P	14	12	0	0	11	0
	Fergus Falls	P	13	9	0	0	14	0
	Little Falls	P	8	10	0	0	0	12
Miss:	Jackson[c]	P	11	13	0(4)	0	6(4)	15
Mo:	Kansas City[c]	P	7	7	0(5)	0	1(5)	1
	St. Louis[c]	P	7	8	0(5)	0	0(5)	2
Mont:	Helena[c]	P	NA	5	0(3)	0	12(3)	6
Nebr:	Omaha[c]	P	6	6	0(4)	0	5(4)	2
Nev:	Las Vegas[c]	P	0	1	0(4)	0	0(4)	0
N.H.:	Manchester[c]	P	11	9	0(4)	0	16(4)	21
N.J.:	Trenton[c]	P	9	9	0(4)	0	4(4)	8
N.Mex:	Albuquerque[c]	P	2	2	0(4)	0	0(4)	1

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for October 1969 and 12-month period, November 1968 through October 1969—Continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES—Continued								
N.Y.:	Buffalo[c]	P	7	7	0(5)	0	2(5)	9
	New York City[c]	P	8	10	0(4)	0	9(4)	13
	Syracuse[c]	P	7	8	0(4)	0	5(4)	9
	Albany	P	(e)	(e)	0(4)	0	(e) (4)	(e)
	Buffalo	P	(e)	3	0	0	(e)	(e)
	Massena	P	4	9	0(2)	0	(e) (2)	(e)
	Newburg	P	10	11	0	0	(e)	(e)
	New York City	P	9	10	0	0	(e) (4)	(e)
	Syracuse	P	(e)	7	0	0	(e)	(e)
N.C.:	Charlotte[c]	P	13	14	0(4)	0	8(4)	12
N.Dak:	Minot[c]	P	10	10	0(4)	0	17(4)	13
Ohio:	Cincinnati[c]	P	7	9	0(5)	0	2(5)	3
	Cleveland[c]	P	8	9	0(5)	0	3(5)	7
Okla:	Oklahoma City[c]	P	8	8	0(4)	0	7(4)	10
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland[c]	P	4	7	0(5)	0	0(5)	7
	Baker	P	NA	2	(e)	(e)	(e)	(e)
	Coos Bay	P	NA	6	(e)	(e)	21	11
	Eugene	P	NA	4	(e)	(e)	(e)	8
	Medford	P	NA	2	(e)	(e)	35	17
	Portland composite	P	NA	3	(e)	(e)	3(5)	6
	Portland local	P	NA	4	(e)	(e)	15(5)	10
	Redmond	P	NA	2	(e)	(e)	(e)	5
	Tillamook	P	NA	5	(e)	(e)	NA	21
Pa:	Philadelphia[c]	P	11	9	0(5)	0	3(5)	5
	Pittsburgh[c]	P	11	12	0(4)	0	3(4)	8
	Dauphin	P	NA	7	0	2	25	15
	Erie	P	15	11	13	5	22	18
	Philadelphia	P	6	9	4	0	17	13
	Pittsburgh	P	13	11	11	1	26	18
R.I.:	Providence[c]	P	5	9	0(4)	0	15(4)	17
S.C.:	Charleston[c]	P	10	11	0(4)	0	24(4)	23
S.Dak:	Rapid City[c]	P	6	7	0(4)	0	0(4)	6
Tenn:	Chattanooga[c]	P	9	11	0(4)	0	11(4)	13
	Memphis[c]	P	8	9	0(5)	0	0(5)	6
	Chattanooga	P	11	13	4(4)	0	19(4)	16
	Clinton	P	NS	16	NS	1	NS	15
	Knoxville	P	11	10	0(2)	0	0(2)	8
	Nashville	P	9	9	8(2)	0	7(2)	5
Tex:	Austin[c]	P	2	2	0(4)	0	4(4)	4
	Dallas[c]	P	7	6	0(4)	0	3(4)	6
	Amarillo	R	NS	4	NS	0	NS	0
	Corpus Christi	R	NS	4	NS	0	NS	0
	El Paso	R	NS	2	NS	0	NS	0
	Fort Worth	R	3	5	0	0	0	20
	Harlingen	R	NS	2	NS	0	NS	0
	Houston	R	5	6	0	0	10	11
	Lubbock	R	NS	3	NS	0	NS	0
	Midland	R	3	2	0	0	0	0
	San Antonio	R	NS	3	NS	0	NS	0
	Texarkana	R	NS	12	NS	0	NS	10
	Uvalde	R	NS	1	NS	0	NS	0
	Wichita Falls	R	NS	6	NS	0	NS	0
Utah:	Salt Lake City[c]	P	9	4	0(4)	0	0(4)	6
Vt:	Burlington[c]	P	8	8	0(4)	0	18(4)	14
Va:	Norfolk[c]	P	12	10	0(5)	0	6(5)	7
Wash:	Seattle[c]	P	5	7	0(5)	0	11(5)	14
	Spokane[c]	P	8	7	0(4)	0	2(4)	5
	Benton County	R	NS	1	NS	0	NS	5
	Franklin County	R	3	2	0	0	0	0
	Sandpoint, Idaho	R	11	11	0	0	28	28
	Skagit County	R	5	7	0	0	16	14
W.Va:	Charleston[c]	P	10	9	0(5)	0	2(5)	7
Wisc:	Milwaukee[c]	P	6	7	0(5)	0	7(5)	11
Wyo:	Laramie[c]	P	6	5	0(5)	0	2(5)	9
CANADA:								
Alberta:	Calgary	P	9	8	(d)		13	15
	Edmonton	P	8	7	(d)		11	14
British Columbia:	Vancouver	P	11	12	(d)		34	35
Manitoba:	Winnipeg	P	8	8	(d)		25	25
New Brunswick	Frederickton	P	15	13	(d)		14	18
Newfoundland:	St. Johns	P	13	17	(d)		34	36
Nova Scotia:	Halifax	P	9	10	(d)		18	20
Ontario:	Ft. William	P	13	16	(d)		33	31
	Ottawa	P	8	9	(d)		14	16

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for October 1969 and 12-month period, November 1968 through October 1969—Continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA: (Continued)								
Ontario:	Sault Ste. Marie	P	9	15	([d])		24	30
	Toronto	P	5	5	([d])		15	12
	Windsor	P	5	6	([d])		12	12
Quebec:	Montreal	P	7	9	([d])		15	18
	Quebec	P	12	11	([d])		26	27
Saskatchewan:	Regina	P	8	7	([d])		14	13
	Saskatoon	P	13	8	([d])		10	12
CENTRAL AND SOUTH AMERICA:								
Columbia:	Bogota	P	1	1	0	0	0	1
Chile:	Santiago	P	0	0	0	0	0	1
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamacia:	Kingston	P	3	5	0	0	35	95
Venezuela:	Caracas	P	2	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	0	1	0(4)	0	13(4)	12
Puerto Rico:	San Juan[c]	P	3	4	0(4)	0	3(4)	7
PMN network average[f]			7	8	0	0	7	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote[c].
NA, no analysis.
NS, no sample collected.

1968 to October 1969. Except where noted the monthly average represents a single sample for the sampling station. Barium-140 levels for all stations were nondetectable during this period. The following station averages reflect samples in which strontium-89 was detected: Kans., Wichita (PMN) 6 pCi/liter; Mo., St. Louis, (PMN) 7 pCi/liter; N. Dak., Minot (PMN) 11 pCi/liter; and S. Dak., Rapid City (PMN) 6 pCi/liter.

Iodine-131 results are included in the table even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting levels for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 22 pCi/liter in the United States for the month of October 1969 and the highest 12-month average was 19 pCi/liter (Del Norte, Calif., and Duluth, Minn.), representing 9.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 93 pCi/liter in the United States for the month of October 1969 and the highest 12-month average was 93 pCi/liter (Southeast Florida), representing 2.6 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 monthly averages were generally below the practical reporting level, with the following exceptions: Pa. (State) Erie, 13 pCi/liter; Philadelphia, 4 pCi/liter; Pittsburgh, 11 pCi/liter; Tenn. (State) Chattanooga, 4 pCi/liter; Nashville, 8 pCi/liter.

Acknowledgement

Appreciation is expressed to the personnel of the following health agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

REFERENCES

(1) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Public Health 49:225 (February 1959).
(2) Chart of the Nuclides, Ninth Edition revised to July 1966. Knolls Atomic Power Laboratory (November 1966).
(3) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).
(4) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).
(5) KNOWLES, F. Interlaboratory study of iodine-131, cesium-137, barium-140, strontium-89, and strontium-90 measurements in milk, July–December 1969. Technical experiment 69-MKAQ-2, Analytical Quality Control Service, Bureau of Radiological Health (October 1969).
(6) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621–627 (November 1967).
(7) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).
(8) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).
(9) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).
(10) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).
(11) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium-89, strontium-90, and cesium-137, Report No. 7. Superindent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).
(12) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The Cause of Relatively High Cesium-137 Concentrations in Tampa, Florida, Milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Issue
California Diet Study	November 1967–September 1968	May 1969
Radionuclides in Institutional Diet Samples, *PHS*	April–June 1969	January 1970
Strontium-90 in Tri-City Diets, *HASL*	August–December 1968	December 1969

1. Estimated daily intake of radionuclides in Connecticut standard diet, July-December 1968, January-June 1969

Connecticut State Department of Health

The Connecticut State Department of Health has been analyzing a standard diet on a monthly basis since March 1963. Analyses are made for strontium-89, strontium-90, and gamma-ray emitters.

The standard diet was selected to represent the food intake of an 18-year-old boy for 1 day (table 1). The total weight of the complete blended diet, averaging 3 kilograms, included milk and dairy products. When raw fruit or vegetables were sampled, they were washed before blending.

Table 1. Foods included in standard diet

Bread, white—8 slices	Ice cream—½ pint
Butter—½ stick	Lettuce, washed—4-5 leaves
Carrots, scraped—½ cup	Milk—3 cups
Celery, washed and trimmed—3 stalks	Oatmeal—uncooked—43 grams
Cookies—4	Orange—1
Cottage cheese—²/₃ cup	Peanut butter—2½ tablespoons
Cupcakes—2	Pears, canned—2 halves with juice
Egg—1	Potatoes, washed, not peeled—2
Green beans, washed—½ cup	Sugar—5 tablespoons
Ham—85 grams	Tomato juice—113 grams
Hamburger—227 grams	Tuna fish, drained—43 grams

Cesium-137 concentrations were determined by gamma-ray spectrometry (*1*). Strontium-89 and strontium-90 concentrations were determined by chemical separation techniques (*1*).

Table 2 presents the analytical results for the Connecticut standard diet from July-December 1968, table 4 shows January-June 1969 data. Results representative of the total daily intake for the radionuclides observed are presented in tables 3 and 5.

Table 2. Radionuclide concentrations in Connecticut standard diet,[a] July-December 1968

Month (1968)	Potassium (g/kg)	Strontium-90 (pCi/kg)	Cesium-137 (pCi/kg)
July	2.0	8.7	10
August	2.1	8.0	30
September	NA	NA	NA
October	1.7	9.3	10
November	2.0	8.5	20
December	NA	NA	NA

[a] All strontium-89 values were <3 for this period.
NA, no analysis.

Table 3. Daily radionuclide intakes in Connecticut standard diet,[a] July-December 1968

Month (1968)	Potassium (g/day)	Strontium-90 (pCi/day)	Cesium-137 (pCi/day)
July	6.0	25.6	40
August	6.4	24.5	90
September	NA	NA	NA
October	5.4	29.6	50
November	6.6	28.0	70
December	NA	NA	NA

[a] All strontium-89 values were <3 for this period.
NA, no analysis.

Table 4. Radionuclide concentrations in Connecticut standard diet,[a] January-June 1969

Month (1969)	Potassium (g/kg)	Strontium-90 (pCi/kg)	Cesium-137 (pCi/kg)
January	2.0	7.1	<10
February	NA	NA	NA
March	2.1	9.7	<10
April	2.0	7.4	10
May	NA	NA	NA
June	2.1	8.9	<10

[a] All strontium-89 values were <3 for this period.
NA, no analysis.

In order to evaluate general trends, strontium-90 and cesium-137 daily intakes are plotted as a function of time in figures 1 and 2.

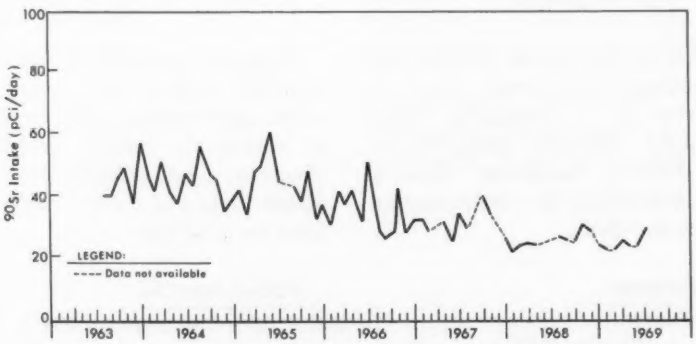

Figure 1. Strontium-90 intake in Connecticut standard diet 1963-June 1969

Table 5. Daily radionuclide intakes in Connecticut standard diet,[a] January–June 1969

Month (1969)	Potassium (g/day)	Strontium-90 (pCi/day)	Cesium-137 (pCi/day)
January	6.2	21.8	<20
February	NA	NA	NA
March	6.3	29.6	<20
April	6.3	23.1	40
May	NA	NA	NA
June	6.5	28.1	<30

[a] All strontium-89 values were <3 for this period.
NA, no analyses.

REFERENCE

(1) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet, March 1963–December 1964. Radiol Health Data 6:381–382 (July 1965).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1967	May 1968
January–June 1968	November 1968

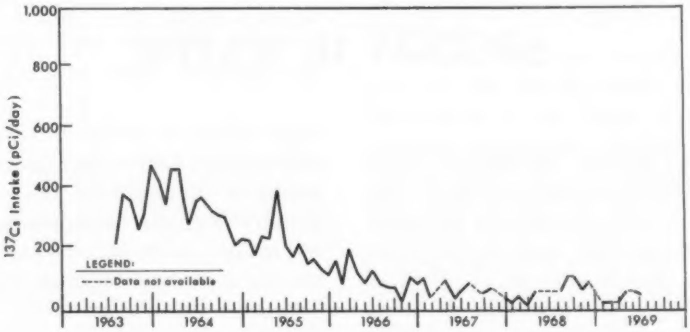

Figure 2. Cesium-137 intake in Connecticut standard diet 1963–June 1969

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January–June 1968	December 1969
Colorado River Basin	1967	December 1968
Minnesota	January–June 1969	January 1970
New York	July–December 1968	September 1969
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	July–December 1968	November 1969
Washington	July 1967–June 1968	June 1969

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Radionuclide Analysis of Coast Guard Supplies January 1968–July 1969

U.S. Coast Guard[1] and
Bureau of Radiological Health[2]

Since 1961, water samples have been collected from seven Coast Guard Loran Stations in Alaska and analyzed for radioactivity. These stations are identified as Adak Island, Attu Island, Biorka Island, Cape Sarichef, Port Clarence, Sitkinak Island, and Spruce Cape. Their locations are shown in figure 1.

The principal source of water for these Loran Stations is either lakes or reservoirs, most of which have ice and snow cover for many of the winter months. Water is piped from the reservoirs to storage tanks at the stations. The storage tanks range in capacity from 25,000 to 225,000 gallons. All of the stations chlorinate the water and all but the Attu Island station filter the water prior to use.

One-gallon samples are collected monthly and sent to the Southwestern Radiological Health Laboratory in Las Vegas, Nev. for analysis. The samples are analyzed routinely for gross alpha and beta radioactivity. Samples are analyzed for specific radionuclides if unusual amounts of gross radioactivity are detected.

Gross alpha and gross beta for the water samples collected during 1968–1969 are shown in table 1.

[1] U.S. Department of Transportation.
[2] U.S. Public Health Service.

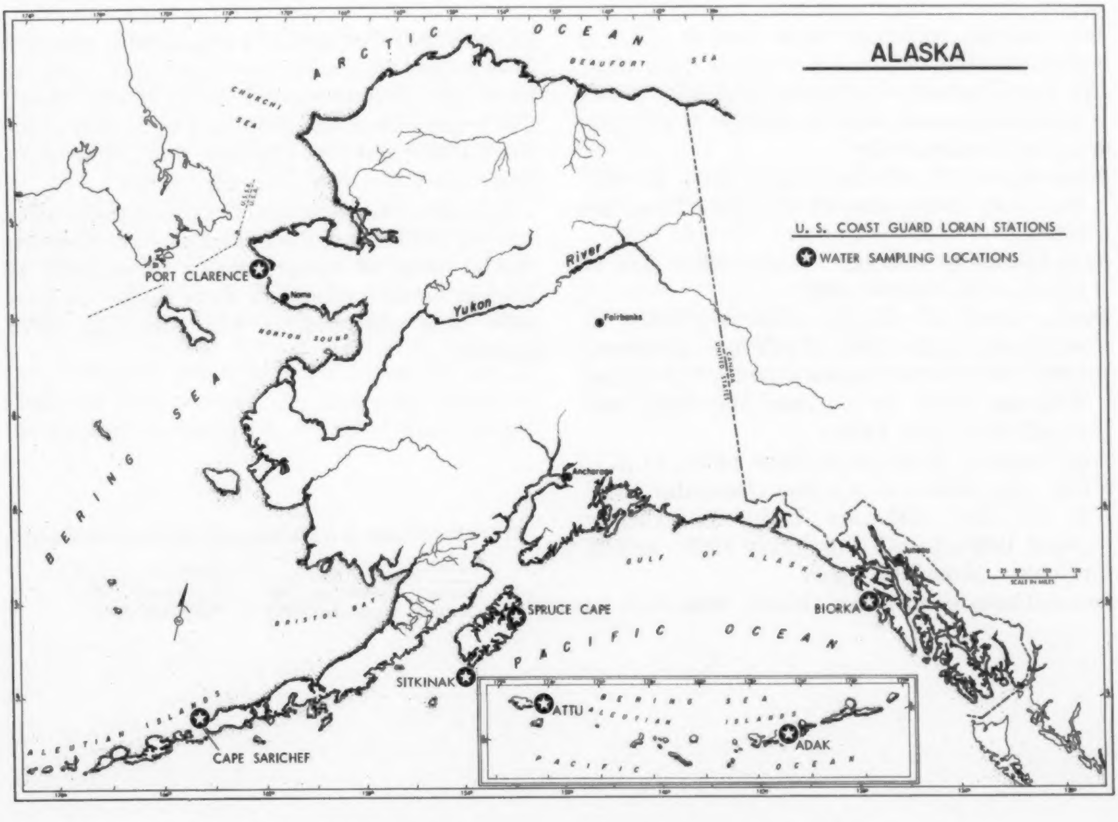

Figure 1. Coast Guard Loran station water sampling locations

Table 1. Radioactivity in water samples (pCi/liter) from U.S. Coast Guard Loran stations, January 1968–July 1969

Months	Adak Island		Attu Island		Biorka Island		Cape Sarichef		Port Clarence		Sitkinak Island		Spruce Cape	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
1968														
January	[a] 0	7	0	[a] 0	NS	NS	0	0	0	8	0	8	0	0
February	0	0	0	5	0	12	0	8	0	9	NS	NS	0	0
March	0	10	0	13	0	9	0	0	0	10	NS	NS	0	0
April	0	13	0	5	0	6	0	4	NS	NS	0	4	0	0
May	0	5	0	4	NS	NS	0	3	0	10	0	4	0	0
June	0	4	0	0	NS	NS	0	0	0	20	0	5	0	8
July	0	11	0	0	0	6	0	5	0	13	NS	NS	0	0
August	0	6	0	4	0	11	0	4	0	10	0	6	0	0
September	0	4	0	0	0	10	0	3	0	6	NS	NS	0	0
October	0	0	0	4	0	10	0	0	0	8	0	4	0	0
November	0	8	0	10	NS	NS	0	5	0	10	0	6	0	5
December	0	12	0	13	0	13	0	9	0	11	NS	NS	0	0
1969														
January	0	4	0	8	0	16	0	0	0	8	NS	NS	0	3
February	0	3	0	7	0	15	0	3	6	19	NS	NS	0	7
March	0	7	NS	NS	NS	NS	0	0	0	8	NS	NS	0	19
April	0	3	0	10	0	10	0	3	0	11	0	8	0	3
May	0	4	0	5	8	16	0	6	0	15	NS	NS	0	0
June	0	3	0	0	0	11	0	4	0	11	NS	NS	0	0
July	0	5	0	3	0	5	0	0	0	0	0	4	0	0

[a] Values equal to or less than 2 pCi/liter gross alpha or gross beta radioactivity are reported as zero.
NS, no samples.

Two samples contained more than 3 pCi/liter gross alpha; Biorka Island, 8 pCi/liter (May 1969) and Port Clarence, 6 pCi/liter (February 1969). Twenty samples contained more than 10 pCi/liter gross beta radioactivity

Adak Island: 13 pCi/liter (April 1968), 11 pCi/liter (July 1968), and 12 pCi/liter (December 1968);

Attu Island: 13 pCi/liter (March 1968), and 13 pCi/liter (December 1968);

Biorka Island: 12 pCi/liter (February 1968); 11 pCi/liter (August 1968), 13 pCi/liter (December 1968), 16 pCi/liter (January 1969), 15 pCi/liter (February 1969), 16 pCi/liter (May 1969), and 11 pCi/liter (June 1969);

Port Clarence, 20 pCi/liter (June 1968); 13 pCi/liter (July 1968); 11 pCi/liter (December 1968) 19 pCi/liter (February 1969), 11 pCi/liter (April 1969), 15 pCi/liter (May 1969), and 11 pCi/liter (June 1969); and

Spruce Cape, 19 pCi/liter (March 1969).

Of these the following had a measureable quantity of strontium-90 greater than 2 pCi/liter: Attu Island, 3 pCi/liter (December 1968); Biorka Island, 3 pCi/liter (December 1968) and 4 pCi/liter (February 1969); and Port Clarence, 6 pCi/liter (June 1968) and 6 pCi/liter (February 1969).

Because of the low levels of environmental radioactivity and because the Radiation Alert Network (RAN) provides comprehensive surveillance of Alaskan Loran stations, the water supply analyses have been discontinued with the July 1969 samples.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
January–December 1966	November 1967
January–December 1967	February 1969

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following program was previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
Fallout in the United States and Other Areas, *HASL*	January–June 1968	October 1969

1. Radiation Alert Network
October 1969

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during October 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, October 1969

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
			Maximum	Minimum	Average[a]		Number of samples	Total depth (mm)	Field estimation of deposition: Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	24	6	1	2	Dec 69	2	40	2	40	17
Alaska:	Adak	25	1	1	1	Dec 69	(c)				
	Anchorage	6	0	0	0	Aug 69	(c)				
	Attu Island	17	0	0	0	Jan 70	(c)				
	Fairbanks	22	3	0	1	Sept 69	3	4	3	4	4
	Juneau	22	4	0	1	Oct 69	9	70	9	70	0
	Kodiak	12	1	0	0	Nov 69	(c)				
	Nome	30	3	0	1	May 69	(c)				
	Point Barrow	29	0	0	0	Feb 70	(c)				
	St. Paul Island	(b)				June 69	(c)				
Ariz:	Phoenix	20	12	1	6	Oct 69	(c)				
Ark:	Little Rock	13	6	0	2	Aug 69	1	19	1	19	0
Calif:	Berkeley	22	2	0	1	Nov 69	3	65	3	65	1
	Los Angeles	21	4	1	2	May 69	(c)				
C.Z:	Ancon	19	1	0	0	Nov 69	(c)				
Colo:	Denver	22	6	0	1	Nov 69	7	72	(d)		
Conn:	Hartford	22	1	0	0	Sept 69	4	122	4	122	0
Del:	Dover	22	3	0	1	July 69	(c)				
D.C:	Washington	27	2	0	0	Feb 70	2	16	2	16	0
Fla:	Jacksonville	22	1	0	1	Aug 69	11	1,626	11	1,626	70
	Miami	16	0	0	0	Sept 69	9	215	3	103	0
Ga:	Atlanta	22	2	1	1	June 69	1	49	1	49	17
Guam:	Agana	(b)				July 69	(c)				
Hawaii:	Honolulu	29	1	0	1	Jan 70	1	4	(d)		
Idaho:	Boise	22	5	1	3	Jan 70	8	17	8	17	2
Ill:	Springfield	11	2	0	1	Feb 70	(c)				
Ind:	Indianapolis	(b)				June 69	(c)				
Iowa:	Iowa City	22	3	0	1	Nov 69	6	90	6	90	0
Kans:	Topeka	23	5	0	2	Aug 69	6	100	6	100	3
Ky:	Frankfort	16	4	1	2	Feb 70	(c)				
La:	New Orleans	23	1	0	1	Feb 70	5	18	(d)		
Maine:	Augusta	23	2	0	1	Oct 69	10	56	9	53	0
Md:	Baltimore	22	1	0	1	Sept 69	4	26	4	26	0
	Rockville	11	1	0	0	Jan 70	(c)				
Mass:	Lawrence	18	4	0	1	Nov 69	3	31	3	31	0
	Winchester	25	4	0	1	Dec 69	5	45	5	45	0
Mich:	Lansing	22	5	0	1	Jan 70	7	61	7	61	7
Minn:	Minneapolis	22	2	0	1	July 69	4	44	4	44	2
Miss:	Jackson	16	1	0	1	Oct 69	3	144	3	144	15
Mo:	Jefferson City	22	3	0	1	June 69	6	151	6	151	0
Mont:	Helena	22	4	0	2	Dec 69	5	36	4	18	6
Nebr:	Lincoln	6	9	2	4	June 69	2	19	2	19	3
Nev:	Las Vegas	17	2	0	1	Sept 69	(c)				
N.H:	Concord	16	2	0	1	Feb 70	(c)				
N.J:	Trenton	21	3	0	1	Oct 69	3	32	3	32	1
N. Mex:	Santa Fe	16	6	0	1	Dec 69	7	74	7	74	10
N.Y:	Albany	14	2	0	1	June 69	4	36	4	36	18
	Buffalo	20	2	0	1	Nov 69	(c)				
	New York City	21	1	0	1	Dec 69	(c)				
N.C:	Gastonia	18	10	0	5	Nov 69	4	46	(d)		
N. Dak:	Bismarck	23	6	1	3	Feb 70	4	5	4	5	1
Ohio:	Cincinnati	(b)				July 69	(c)				
	Columbus	3	2	1	1	Oct 69	1	18	(e)		
	Painesville	22	2	0	1	Sept 69	11	111	11	111	9
Okla:	Oklahoma City	13	4	0	2	Jan 70	6	34	5	31	1
	Ponca City	22	7	0	2	Sept 69	4	44	4	44	0
Ore:	Portland	21	2	0	1	June 69	13	98	13	98	6
Pa:	Harrisburg	22	2	0	1	June 69	(c)				
P.R:	San Juan	(b)				Oct 69	(c)				
R.I:	Providence	22	8	0	1	Jan 70	5	52	5	52	6
S.C:	Columbia	20	5	0	2	Dec 69	1	21	1	21	0
S. Dak:	Pierre	10	6	1	4	Oct 69	(c)				
Tenn:	Nashville	22	4	0	1	Jan 70	6	42	6	42	0
Tex:	Austin	22	7	1	4	July 69	(c)				
	El Paso	(b)				Feb 70	(c)				
Utah:	Salt Lake City	31	4	0	2	May 69	8	43	8	43	10
Vt:	Barre	19	5	0	2	Aug 69	7	57	7	57	7
Va:	Richmond	23	2	0	1	Aug 69	2	52	2	52	6
Wash:	Seattle	4	0	0	0	Aug 69	7	39	(d)		
	Spokane	22	4	1	2	July 69	(c)				
W. Va:	Charleston	21	4	0	2	Dec 69	4	48	4	48	7
Wisc:	Madison	23	2	0	1	Aug 69	7	78	6	77	11
Wyo:	Cheyenne	23	5	0	1	Sept 69	6	56	6	56	2
Network summary		1,321	12	0	1		6	103	5	95	6

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

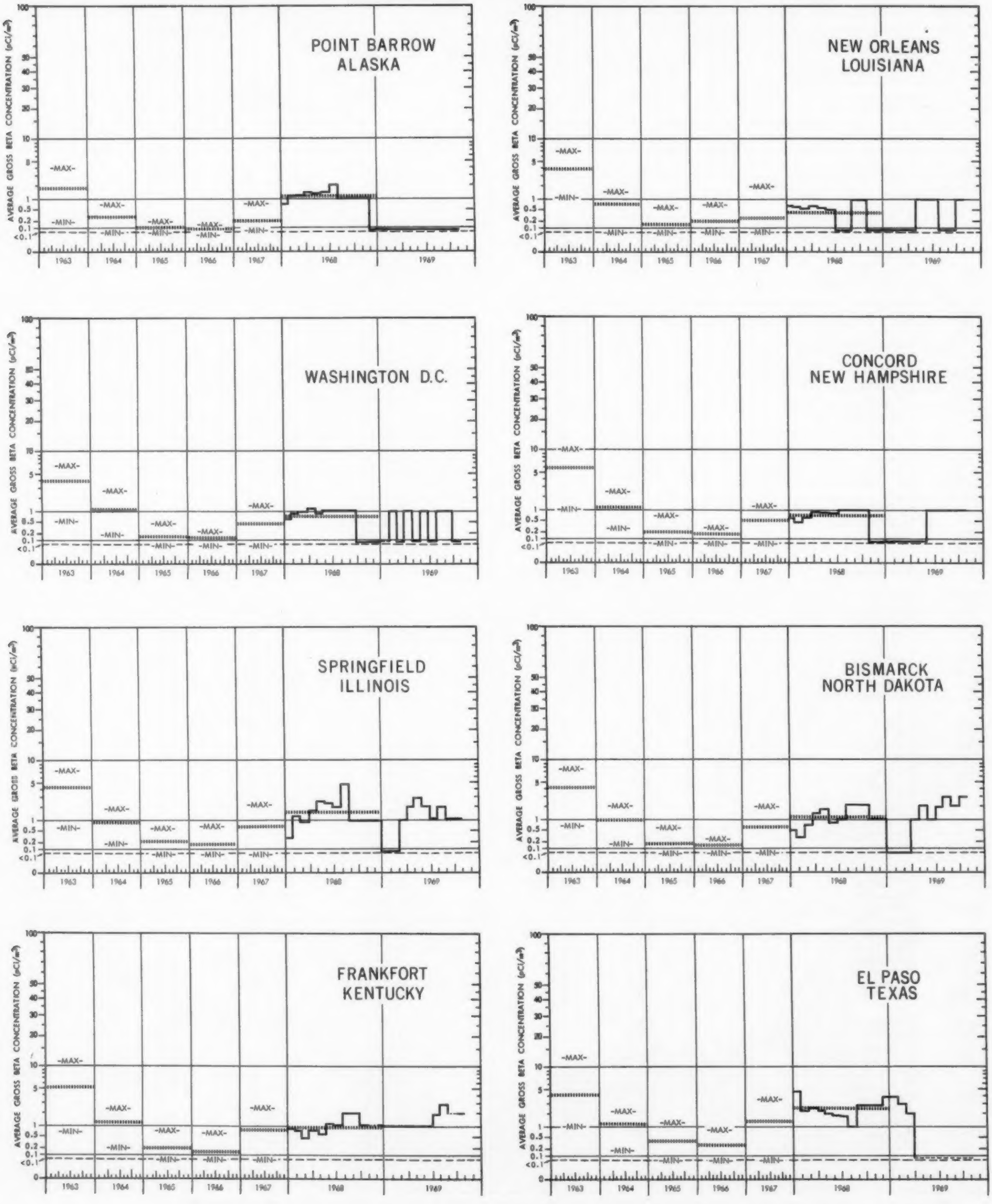

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1963–October 1969

2. Canadian Air and Precipitation Monitoring Program[1], October 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for October 1969 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, October 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.2	0.0	0.1	29	0.9
Coral Harbour	31	.1	.0	.1	NS	NS
Edmonton	29	.2	.0	.1	40	1.2
Ft. Churchill	21	.1	.0	.1	19	.9
Ft. William	31	.2	.0	.1	59	2.3
Fredericton	31	.2	.0	.1	31	1.9
Goose Bay	31	.1	.0	.1	15	.8
Halifax	30	.2	.0	.1	22	2.2
Inuvik	31	.1	.0	.1	396	.5
Montreal	31	.2	.0	.1	27	2.3
Moosonee	30	.2	.0	.1	10	.6
Ottawa	31	.2	.0	.1	15	.6
Quebec	31	.1	.0	.1	37	2.8
Regina	31	.2	.0	.1	16	1.0
Resolute	30	.1	.0	.1	10	.2
St. John's, Nfld	29	.2	.0	.1	15	3.0
Saskatoon	31	.2	.0	.1	18	1.2
Saulte Ste. Marie	31	.2	.0	.1	21	3.0
Toronto	30	.3	.0	.1	40	2.3
Vancouver	31	.2	.0	.1	38	3.7
Whitehorse	31	.1	.0	.1	255	.6
Windsor	31	.2	.0	.1	23	1.2
Winnipeg	31	.2	.0	.1	63	1.7
Yellowknife	31	.1	.0	.1	162	1.3
Network summary	726	0.3	0.0	0.1	59	1.6

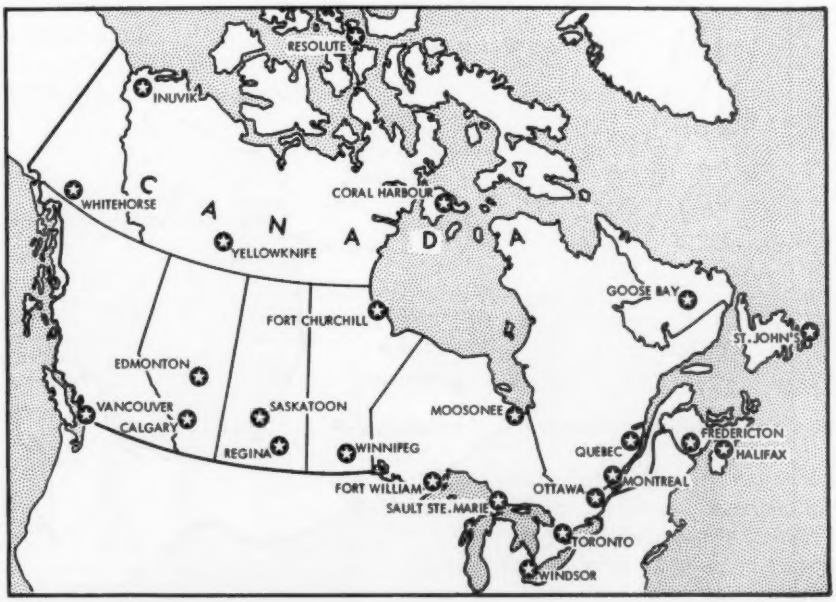

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program May and June 1969

National Commission of Nuclear Energy México, D.F.

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F., Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Prevision del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Deserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Seccion de Radioactividad Ambiental, CNEN, in Mexico, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*6*).

The maximum, minimum, and average beta radioactivity in surface air during May and June 1969 are presented in tables 3 and 4.

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, May 1969

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	NS			
Chihuahua	15	0.6	0.1	0.3
Ciudad Juares	1	.6		
Ensenada	NS			
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	3	.6	.5	.5
Mérida	15	.5	.1	.3
México, D.F.	1	.2		
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	NS			
Torreón	7	1.4	.1	.1
Veracruz	8	.1	.6	.3

NS, no sample, station temporarily shutdown.

Table 4. Mexican gross beta radioactivity of airborne particulates, June 1969

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	19	0.8	0.3	0.3
Chihuahua	9	1.6	.5	.9
Ciudad Juarez	NS			
Ensenada	4	.7	.2	.4
Guadalajara	NS			
Guaymas	NS			
La Paz	10	.7	.2	.4
Matamoros	NS			
Mazatlan	NS			
Mérida	3	.3	.1	.3
México, D.F.	NS			
Nuevo Laredo	7	1.5	.2	.9
San Luis Potosí	NS			
Tampico	NS			
Torreón	22	.7	.1	.5
Veracruz	11	1.2	.1	.5

NS, no sample, station temporarily shutdown.

4. Pan American Air Sampling Program October 1969

Pan American Health Organization and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health program.

Table 5. Summary of gross beta radioactivity in Pan American surface air, October 1969

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	21	0.18	0.05	0.10
Bolivia:	La Paz	17	.12	.03	.07
Chile:	Santiago	29	.27	.04	.13
Colombia:	Bogota	20	.04	.00	.01
Ecuador:	Cuenca	NS	NS	NS	NS
	Guayaquil	5	.08	.02	.06
	Quito	11	.04	.00	.01
Guyana:	Georgetown	NS	NS	NS	NS
Jamaica:	Kingston	19	0.24	.01	.06
Peru:	Lima	NS	NS	NS	NS
Venezuela:	Caracas	22	.08	.01	.02
West Indies:	Trinidad	22	.04	.00	.02
Pan American summary		166	0.27	0.00	0.06

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ arereported and used in averaging as 0.00 pCi/m³.
NS, no sample.

Figure 5. Pan American Air Sampling Program stations

The air sampling locations are shown in figure 5. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The October 1969 air monitoring results from the participating countries are given in table 5.

5. Plutonium in Airborne Particulates and Precipitation, July–September 1968

Bureau of Radiological Health
U.S. Public Health Service

The Radiation Alert Network (RAN) of the Bureau of Radiological Health, Public Health Service, routinely analyzes airborne particulate and precipitation samples from selected RAN stations for plutonium. The airborne particulate and precipitation analyses were initiated in November 1965 and August 1966, respectively, and the results through June 1968 have been previously reported (*7–15*).

Air filters from 11 RAN stations are analyzed for plutonium. A monthly composite is made of one-half of each individual air filter from each of the 11 stations and sent to the PHS Northeastern Radiological Health Laboratory (NERHL) for analysis. Eight RAN stations submit complete collections of precipitation for plutonium analysis. An 8-liter (or whatever is available) aliquot of the monthly collection of each of the 8 stations is forwarded to the NERHL for analysis. The analytical methodology for processing these samples is described in the December 1968 issue of *Radiological Health Data and Reports* (*14*).

The results for July through September 1968 are presented in tables 6 and 7. ND (nondetectable) has been used to indicate samples containing plutonium-238 or plutonium-239 activities less than or equal to the appropriate minimum detectable activities (.020 pCi and .015 pCi per sample for plutonium-238 and plutonium-239, respectively). Sample size varies, generally ranging from 20,000 to 30,000 cubic meters of air for the air filter samples, and from 2 to 8 liters for the precipitation samples.

Table 6. Plutonium-238 and plutonium-239 in precipitation, July–September 1968

	Anchorage	Denver	Honolulu	New Orleans	Gastonia	Rockville	Austin	Seattle
Precipitation depth (mm): July–September	61	87	20	71	59	95	65	142
Concentration (pCi/liter): Plutonium-239 July–September	.056	.022	ND	.107	.021	.015	ND	.047
Plutonium-238 July–September	ND	ND	ND	.129	ND	ND	.059	ND
Deposition (pCi/m^2): Plutonium-239 July–September	3.36	1.87		7.49	1.21	1.39		6.58
Plutonium-238 July–September				9.03			3.84	

ND, nondetectable.

Table 7. Plutonium in airborne particulates, July–September 1968

	Buffalo	Gastonia	Rockville	Pierre	New Orleans	Austin	Denver	Anchorage	Phoenix	Honolulu	Seattle
Plutonium-238 (fCi/m^3) July–September	ND	0.024	ND	0.045	ND	ND	ND	ND	ND	ND	0.033
Plutonium-239 (fCi/m^3) July–September	.098	.124	.056	.176	.091	.071	.060	.052	.102	.031	.041
$^{239}Pu/^{238}Pu$ July–September		5.17		3.91							1.24

ND, nondetectable.

REFERENCES

(1) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(6) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Méxicana, 1963-1965. Comisión Nacional de Energía Nuclear, Direccion General de Seguridad Radiologica (1966).

(7) RUSSELL, J., H. LEVINE, R. SCHNEIDER. Plutonium in airborne particulates, November 1965 through March 1966. Radiol Health Data Rep 7:483-484 (August 1966).

(8) DIVISION OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates, April-June 1966. Radiol Health Data Rep 7:666-667 (November 1966).

(9) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, July-September 1966. Radiol Health Data Rep 8:108-109 (February 1967).

(10) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, October-December 1966. Radiol Health Data Rep 8:288-289 (May 1967).

(11) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, January-March 1967. Radiol Health Data Rep 8:534 (September 1967).

(12) LEVINE, H., W. P. KIRK, H. J. L. RECHEN. Plutonium and strontium-90 in precipitation, August 1966 through March 1967. Radiol Health Data Rep 8:574-576 (October 1967).

(13) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates and precipitation and strontium-90 in precipitation, April-June 1967. Radiol Health Data Rep 8:662-663 (November 1967).

(14) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates and precipitation, July-December 1967. Radiol Health Data Rep 9:761-763 (December 1968).

(15) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates and precipitation, January-March 1968. Radiol Health Data Rep 10:34-35 (January 1969).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Argonne National Laboratory and the Rocky Flats Plant.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Argonne National Laboratory[2] July–December 1968

University of Chicago
Lemont, Ill.

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally-occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed in this report are shown in figures 1 and 2.

Air monitoring

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. The alpha and beta radioactivity in airfilter samples are summarized in table 1. The alpha radioactivity concentrations were normal both on and off the site and in the range found in previous years. As in the past, much of the beta and gamma radioactivity was due to fission and neutron activation products from nuclear detonations, although about one-third of the gamma radioactivity and a smaller fraction of the beta radioactivity was due to beryllium–7, produced continuously in the upper atmosphere by cosmic-ray interactions. The variation in total beta radioactivity during the year can be correlated with the concentrations of the individual gamma-ray emitters. The beta radioactivity decreased during the year from an average of 0.25 pCi/m^3 during the first half to an average of 0.12 pCi/m^3 during the last 6 months. This decrease was due to the disappearance by radioactive decay of the shorter-lived fission products, primarily zirconium–niobium–95. By the end of the year, the short-lived fission products were below their minimum detectable concentrations, although traces of these nuclides (<0.01 pCi/m^3) were also detected in August and September. While the longer-lived gamma-ray emitters also decreased somewhat in concentration during the

[2] Summarized from "Environmental Radioactivity at Argonne National Laboratory, July–December 1968," University of Chicago, Lemont, Ill.

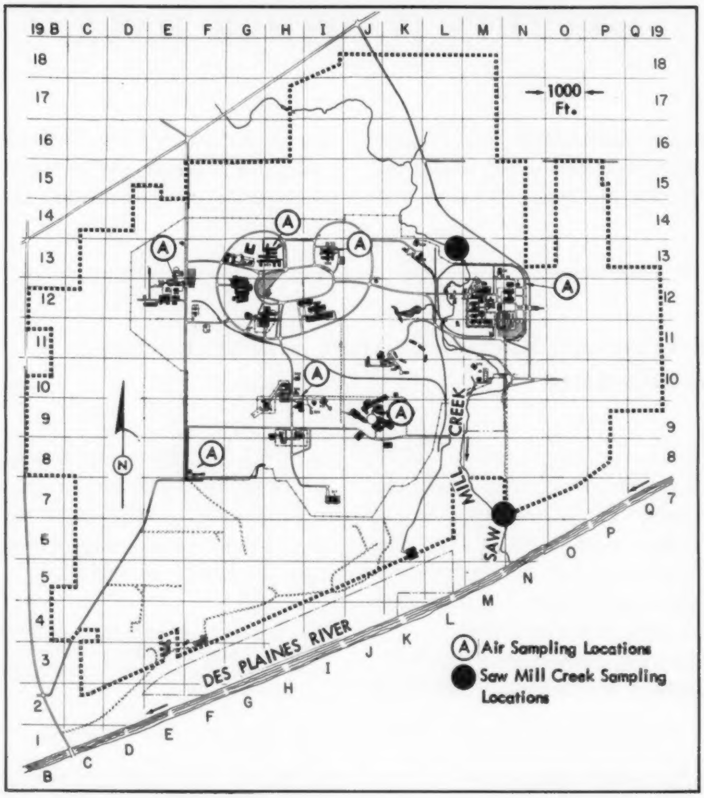

Figure 1. Onsite sampling locations at Argonne National Laboratory

Table 1. Alpha and beta radioactivity in air-filter samples,[a] Argonne National Laboratory, July–December 1968

Period	Location	Number of samples	Alpha radioactivity (pCi/m^3) Multiply by 10^{-2}			Beta radioactivity (pCi/m^3) Multiply by 10^{-2}		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Onsite	27	0.40	0.20	1.02	0.21	0.09	0.32
	Offsite	22	.58	.27	1.38	.22	.15	.32
August	Onsite	25	.42	.22	.85	.15	.10	.25
	Offsite	22	.36	.11	.58	.16	.08	.27
September	Onsite	24	.47	.23	.86	.13	.09	.16
	Offsite	17	.52	.27	1.01	.13	.09	.19
October	Onsite	24	.43	.18	1.15	.09	.05	.14
	Offsite	23	.51	.24	1.22	.09	.06	.14
November	Onsite	26	.25	.10	.39	.06	.03	.11
	Offsite	19	.30	.08	.51	.08	.04	.14
December	Onsite	22	.26	.16	.32	.07	.03	.14
	Offsite	17	.35	.16	.89	.08	.03	.16
Annual summary	Onsite	301	0.42	0.10	1.15	0.18	0.03	0.51
	Offsite	250	0.48	0.08	1.38	0.19	0.03	0.51

[a] These results were obtained by measuring the samples 4 days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products.

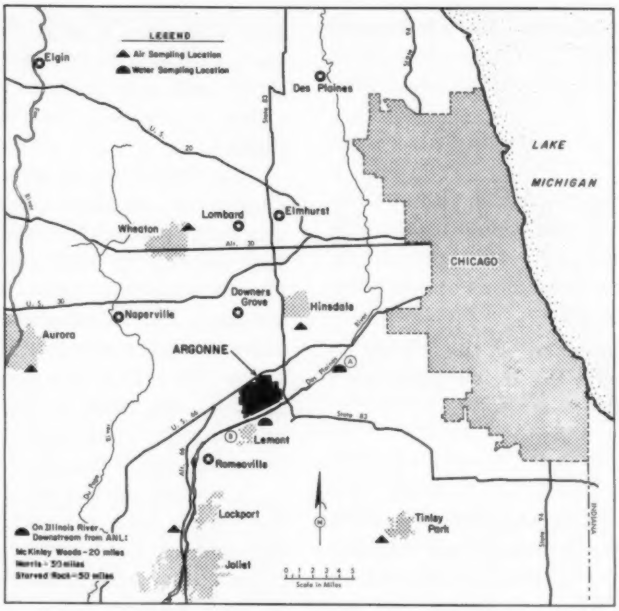

Figure 2. Location of Argonne National Laboratory (including some offsite sampling stations)

last half of the year, their effect on the total beta radioactivity was not as marked because they were present in lower concentrations than the short-lived activities. Precipitation collected on the site contained the same fission products found in the air samples. Large volume rain samples were also analyzed for iron–55, a neutron activation product produced in nuclear detonations. Monthly composite samples were analyzed for this nuclide from July to December 1968. Concentrations ranged from 0.014 to 0.14 nCi/m² and averaged 0.048 nCi/m² (corrected for decay back to October 15, 1961).

Sampling on charcoal, specifically for gaseous radioiodine, was conducted continuously on the site. No activity above the minimum detectable concentration of 0.1 pCi/m³ was detected during this time period.

Air sampling for argon–41, which is produced in the reactor by neutron activation of the stable argon in the air used for cooling, was conducted near the CP–5 reactor (Building 330) beginning in May. The sampling locations ranged from 50 to 565 yards from the reactor. Results are tabulated in table 2. The average and maximum concentrations of 140 and 1,400 nCi/m³ are about 3.5 and 35 times greater than the AEC standard

Table 2. Argon–41 concentrations near CP–5 reactor, May–December 1968

Month	Number of samples	Number of samples >20 nCi/m³	Concentration (nCi/m³)	
			Average	Minimum
May	7	4	150	800
June	16	11	180	850
July	31	11	110	1,400
August	34	21	130	730
September	34	15	80	270
October	30	13	130	990
November	32	14	150	750
December	26	8	160	570

for argon–41 (40 nCi/m³). However, each sample was collected over a period of about 1 minute and was taken downwind after the reactor had been in operation for several hours. Therefore, the actual average concentration in the 300 area was much less than the values in the table.

Air sampling for tritiated (hydrogen–3) water vapor was carried out 50-yards west of the CP–5 reactor. The results are given in table 3. The maximum concentration corresponds to 0.88 percent of the AEC standard (200 nCi/m³). Control samples collected in the east area contained less than the minimum detectable concentration of

Table 3. Hydrogen-3 concentrations near CP-5 reactor June-December 1968

Month	Number of samples	Concentration (pCi/m^3)			Percent AEC standard	
		Average	Minimum	Maximum	Average	Maximum
June	10	28	<15	47	0.014	0.024
July	26	270	<15	1,760	.14	.88
August	12	84	<15	570	.042	.29
November	1			120		.060
December	5	210	<15	640	.11	.32

15 pCi/m^3. Tritium is produced in the reactor by the action of neutrons on the heavy water used for cooling and moderating.

Water monitoring

Argonne wastewater is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500-yards downstream from the wastewater discharge. Sawmill Creek was sampled above and below the discharge to evaluate the effect of the wastewater on the radioactivity in the creek. The sampling locations are shown in figure 2.

Below the wastewater outfall, the creek was usually sampled three to five times weekly. Since it was impractical to analyze all the samples for all the radionuclides and elements desired, equal portions of the three samples collected each week were combined and analyzed. The results obtained in this way represent the average concentrations in the weekly samples. Above the site, samples were collected at semimonthly intervals, and at least one sample each month was analyzed for each radioactive nuclide of interest. The total alpha and beta radioactivity found in Sawmill Creek during July–December 1968 are given in table 4.

The alpha-particle emitters most likely to be present in Argonne wastewater are isotopes of uranium, plutonium, and thorium. The alpha radioactivity in the creek water due to these elements are summarized in table 5. The average uranium concentrations below the outfall was about 30 percent higher than during 1967; while above the outfall, the concentration averaged essentially the same as last year. The plutonium and thorium concentrations averaged less than the minimum detectable amount.

In addition to the natural beta radioactivity in the creek, beta radioactivity from fallout was detected at both sampling locations and beta radioactivity from Argonne wastewater was found in some samples below the outfall. The natural beta radioactivity is approximately 5 pCi/liter above the site and 3 pCi/liter below the site. It is estimated that fallout activity added an average of about 11 pCi/liter to the beta radioactivity at both locations, and that the Argonne contribution below the outfall averaged approximately 7 pCi/liter, about one-third less than in 1967.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two streams is important in assessing the contribution of Argonne wastewater to the environmental radioactivity. The Des Plaines River was sampled

Table 4. Non-volatile alpha and beta radioactivity in Sawmill Creek water, Argonne National Laboratory July-December 1968

Month (1968)	Location[a]	Number of samples	Alpha radioactivity (pCi/liter)			Beta radioactivity (pCi/liter)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Upstream	2	1.7	1.5	1.9	18	15	20
	Downstream	12	1.3	1.0	1.7	11	7	14
August	Upstream	2	2.2	1.8	2.6	16	9	24
	Downstream	15	2.1	1.2	3.0	12	8	18
September	Upstream	2	3.1	2.8	3.4	23	21	25
	Downstream	12	1.4	.6	2.2	10	9	12
October	Upstream	2	3.7	3.6	3.8	23	16	29
	Downstream	12	1.9	1.0	3.3	11	10	12
November	Upstream	2	2.1	2.0	2.3	19	13	26
	Downstream	17	1.9	1.3	2.7	15	12	20
December	Upstream	2	2.3	2.1	2.4	9	8	11
	Downstream	20	2.8	2.4	4.0	13	11	14
July–December 1968 summary	Upstream	12	2.5	1.5	3.8	18	8	29
	Downstream	88	1.9	0.6	4.0	12	7	20
Annual summary	Upstream	24	2.8	1.5	4.5	16	8	33
	Downstream	166	2.4	0.6	9.9	21	7	93

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

Table 5. Alpha-particle emitting elements in Sawmill Creek water, Argonne National Laboratory July–December 1968

Element	Location[a]	Number of samples	Concentration (pCi/liter)			Average as a percent of AEC standard
			Average	Minimum	Maximum	
Uranium	Upstream	7	1.4	0.8	2.1	0.004
	Downstream	36	1.3	.5	1.9	.003
Plutonium	Upstream	6			< .05	
	Downstream	12	<0.05	<.05	.06	< .001
Thorium	Upstream	6			< .05	
	Downstream	12	< .05	<.05	.14	< .003

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

monthly above the mouth of Sawmill Creek and weekly below the mouth to determine if the radioactivity in the creek had any effect on the radioactivity in the river. The total radioactivity is summarized in table 6. The average concentrations were very similar at both locations, indicating that Sawmill Creek water had no significant effect on the radioactivity in the river. The alpha and beta radioactivities were not significantly different from the 1967 averages. The natural beta radioactivity in the river is 5 to 10 pCi/liter, and the additional radioactivity, about 7 pCi/liter on the average, was due to fallout. The total activities in samples of Illinois River water were similar to those found in other bodies of water in the area and to the activities found previously at these same locations, and no radioactivity originating at Argonne could be detected.

Table 6. Average radioactivity in Des Plaines and Illinois River water, Argonne National Laboratory, July–December 1968

Location	Concentration (pCi/liter)	
	Non-volatile alpha radioactivity	Non-volatile beta radioactivity
Des Plaines River[a] (above Sawmill Creek)	3.7	15
Des Plaines River[b] (below Sawmill Creek)	3.4	14
Illinois River[c]	1.7	9

[a] Samples near Route 45, upstream from the mouth of Sawmill Creek.
[b] Sampled near Lemont, downstream from the mouth of Sawmill Creek.
[c] Average for samples collected at four locations (McKinley Woods State Park, June 6 and October 9, Morris, and Starved Rock State Park on October 9, 1968.

Radioactivity in milk

Raw milk was collected monthly from a local dairy farm and analyzed for several fission products. Strontium–89, iodine–131, and barium–140, were not present in concentrations greater than the minimum detectable amounts of 20 pCi/liter for iodine–131 and 3 pCi/liter for the other two radionuclides. The strontium–90 and cesium–137 concentrations are given in table 7. These two radionuclides are long-lived fission products from past nuclear tests and their presence in milk is not related to Argonne operations. The strontium–90 content averaged approximately 25 percent lower, and the cesium–137 content about 40 percent lower than during 1967.

Table 7. Fission product concentrations in milk ANL, July–December 1968

Data collected	Concentrations (pCi/liter)	
	Cesium–137	Strontium–90
January 3	30	5.8
February 7	30	5.8
March 6	35	7.7
April 4	30	8.8
May 2	40	8.6
June 5	60	7.0
July 3	35	3.8
August 7	26	2.7
September 4	37	3.1
October 2	25	5.5
November 6	29	2.2
December 4	45	5.9
Average	36	5.6

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1967	August 1968
January–June 1968	May 1969

2. Rocky Flats Plant[3] January–June 1969

Dow Chemical Company
Golden, Colo.

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location, relative to population centers, is shown in figure 3. To assure properly controlled releases of radioactive materials to the environment, periodic samples of air, water, and vegetation are analyzed for gross alpha radioactivity. The most abundant radioactive material involved in the process is plutonium.

The plant is located about 10 air miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized front range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

[3] Summarized from "Environmental Survey, January–June 1969," The Dow Chemical Company, Rocky Flats Division, Golden, Colo.

Air

Continuous air samples were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner School, Golden, Denver, and Westminster. The monthly average long-lived gross alpha radioactivity shown in table 6 is believed to result from naturally occurring materials. All values are less than the AEC standard of 40 fCi/m^3 for mixtures of unidentified radionuclides.

Table 6. Long-lived gross alpha radioactivity in airborne particulates, RFP environs, January–June 1969

Period	Average concentration (fCi/m^3)
January	5
February	4
March	3
April	4
May	3
June	3

Water

Regular water samples were obtained monthly except during the winter months from four reser-

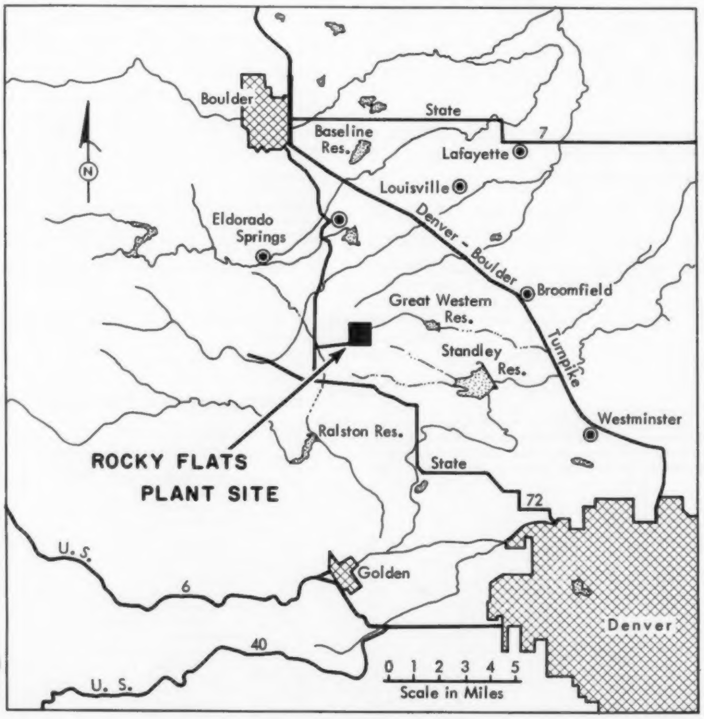

Figure 3. Location of Rocky Flats Plant

voirs in the area of the Rocky Flats Plant. The results of alpha radioactivity analyses performed on these samples are given in table 7. Following a fire on May 11, 1969, in a plutonium-processing building (appendix 1), additional samples were collected from Great Western and Standley Reservoirs. For comparison purposes, the AEC standard for mixtures of unidentified radionuclides in water is 10 pCi/liter.

Table 7. Alpha radioactivity in water, RFP environs, January–June 1969

Reservoir	Number of samples	Average concentration (pCi/liter)
Great Western	20	2.2
Standley	20	1.8
Baseline	3	.9
Ralston	6	3.4
All other locations (collected May–June 1969)	52	1.8

Vegetation

Vegetation samples collected in October 1968 and May 1969 are summarized in table 8.

Table 8. Alpha radioactivity in vegetation, RFP environs

Collection period	Distance from plant	Number of samples	Average concentration (pCi/kg dry weight)
October 1968	<4 miles	62	90
	4–18 miles	44	96
May 1969	<4 miles	39	84
	4–18 miles	20	77

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1968	June 1969

Appendix I.

Report on the fire at the Rocky Flats Plant near Boulder, Colo., by the U.S. Atomic Energy Commission on May 11, 1969[1]

On May 11, 1969, a major fire occurred at the Rocky Flats (Colorado) Plant of the Atomic Energy Commission (AEC). The Rocky Flats Plant, which produces plutonium parts for nuclear weapons, is located approximately 10 air miles northwest of Denver, between Golden and Boulder. The facility is operated for the AEC by the Dow Chemical Company under a contract administered by the Rocky Flats Area Office of the AEC's Albuquerque Operations Office.

The fire occurred in Building 776–777 (figure 4) which is used for manufacturing plutonium parts. This building is a complex facility which has been rearranged and modified repeatedly over the years to meet changing production requirements and schedules. The equipment in Building 776–777 includes various types of machinery operated in "glovebox" systems (figure 5).

The gloveboxes are under a slight negative pressure with respect to the air in the room around them. Although they are fairly well sealed, air enters the gloveboxes from the room in which they are housed and exits through ducts to filtered systems on the roof. This provides a means for working safely with plutonium while separating the operator from this potentially hazardous radioactive material. Gloveboxes have portholes which are sealed by rubber gloves which workers use to perform operations in the boxes. The gloveboxes used in related system operations are connected by conveyor lines. In turn, the systems are interconnected by other conveyor lines, by which plutonium is transferred from one operation to another. The conveyor lines connecting the gloveboxes are long enclosed tunnels lined with plastic windows. In some areas, thick pieces of either plastic or cellulosic laminate material (made from wood chips) have been placed on the inside or outside of the gloveboxes and conveyor lines as radiation shielding.

The first indication of a fire was an alarm received in the plant's fire station at 2:27 p.m. on May 11 from the heat-sensing system which monitors temperatures at various locations in the glovebox systems in Building 776–777. Although the fire department responded promptly, the dense smoke, crowded conditions, and presence of large

[1] Summarized from AEC Release No. 257, November 18, 1969.

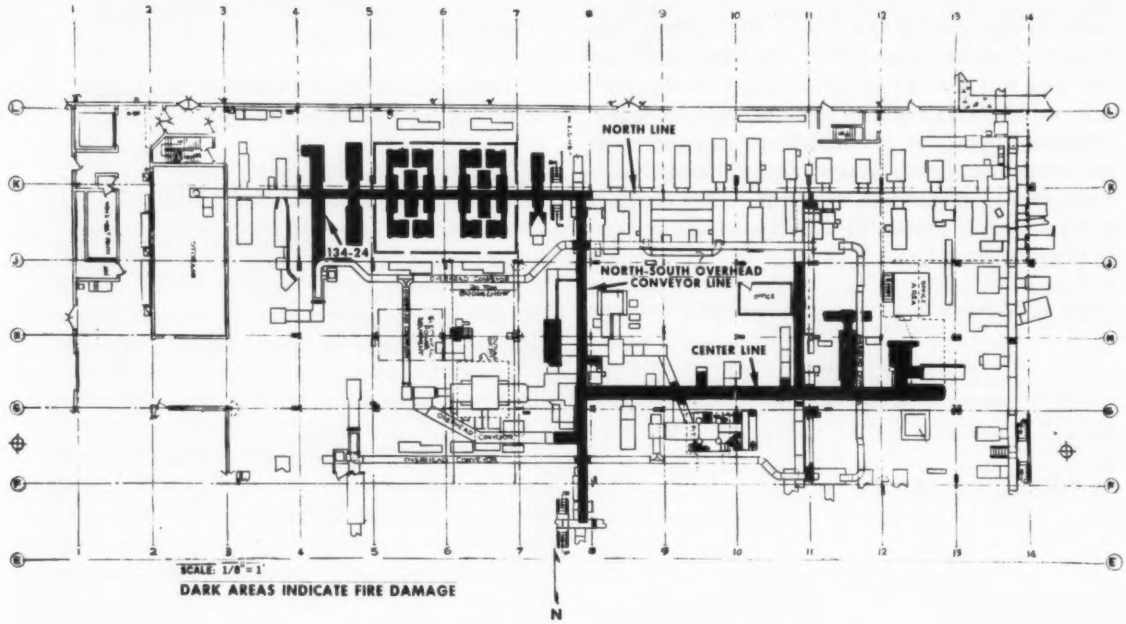

Figure 4. Fire damage to building 776, Rocky Flats Plant

quantities of combustible shielding material made the fire very difficult to fight and extinguish. Because of the concern about the possibility of a nuclear criticality accident (a chain reaction), the standard firefighting procedures in effect for Building 776–777 did not specify the use of water except as a last resort. For this reason, there was no automatic sprinkler system in this area of the building. The first attack on the fire was made with CO_2 and was ineffective. Less than 10 minutes after the fire alarm was received, the fire captain initiated the use of water. Thereafter,

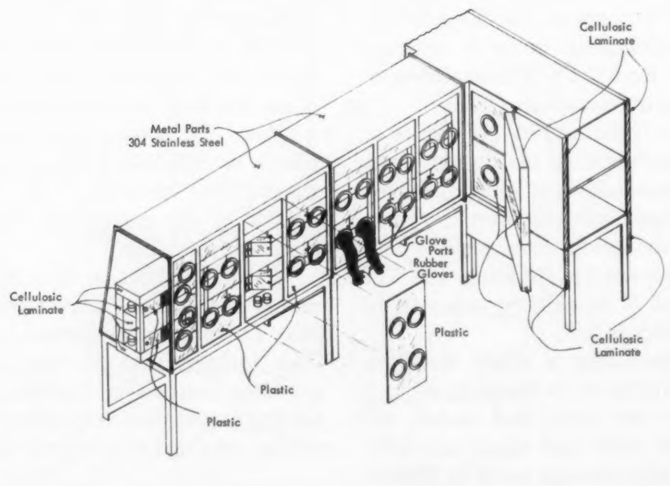

Figure 5. Glovebox 134–24

water was used almost exclusively in the firefighting activities. No nuclear criticality occurred. The fire was brought under control about 6:40 p.m., but continued to burn or recur in isolated areas throughout the night.

The fire originated within the north line, moved rapidly through the north–south overhead conveyor line, and subsequently spread through one of the interconnecting conveyors and into the center line. Some plutonium contained in these lines burned, and as the glovebox windows burned out, plutonium oxide was released into the room. (Note: When plutonium metal burns, it converts to the oxide form from which it can again be converted to metal without significant loss of material.) Because of the extensive plutonium contamination and smoke, all personnel entering the area during the fire were required to use self-contained breathing air systems which severely limited both access to, and time in, the fire area. There were no lost time injuries from the fire or the firefighting, although one firefighter inhaled some plutonium most of which was quickly eliminated following treatment.

The damage to Building 776–777 and its equipment was extensive. In addition to the actual fire and smoke damage, the building was heavily contaminated internally with plutonium. Substantial parts of the utility systems within the building were severely damaged. Some of the interconnected buildings sustained minor interior contamination. The fire did not breach the building roof, but slight exterior contamination was measured on the roof of Building 776 and an adjoining building, apparently due to a minor failure of a filter. Plutonium also was tracked out of Building 776 by the firefighters and was detectable on the ground around the building. There is no evidence that plutonium was carried beyond the plant boundaries.

The available evidence indicates that the fire originated on the lower shelf of the storage cabinet in glovebox 134–24 in the north line. Plutonium briquettes (discs 3 inches in diameter and 1-inch thick of either pressed scrap metal or lathe turnings) and some loose scrap metal were stored in uncovered cans in the storage cabinet. The exact cause of ignition is unknown; however, plutonium in the form of chips or lathe turnings is a pyrophoric material. The heat from the burning plutonium metal evidently caused the storage cabinet, which was constructed mostly of cellulosic laminate material and plastic, to char and generate flammable gases which could have been ignited by burning plutonium. The heat of the burning gases could ignite other briquettes and initiate a slow burning of the storage cabinet materials, particularly in the cracks between the joined sections of the cellulosic materials.

The smoke in the exhaust system of the north line gradually clogged the filters. Flames erupted on the outer surfaces of the cabinet and spread to the combustible gloves and plastic windows on glovebox 134–24. Up to this time, the fire was still undetected by the few people who were in the building that day because the smoke, flames, and heat were contained within the glovebox system. Since the heat detectors were located outside and under glovebox 134–24 and were insulated by the floor of the storage cabinet, they were incapable of sensing the fire. (Similar detectors elsewhere in the glovebox system subsequently did function, and the alarm was sounded.)

Once the plastic windows of glovebox 134–24 were breached, the inrushing air fanned the fire and caused it to spread into the north conveyor line and the gloveboxes east of glovebox 134–24.

The airflow in the north conveyor line normally goes from east to west. However, because of the clogged filters, the airflow in the line reversed and followed the second ventilation system which is part of the north–south overhead conveyor line and the center line. When the fire reached the north–south line, it turned south because of two factors; a closed metal door in the north line, and the direction of the airflow. On reaching the center line, the fire again went east because of the airflow.

Decontamination, cleanup, and installation of equipment in the fire-damaged building have made possible the resumption of developmental production, even though not yet full scale. About 80 percent of the 211,000 square-foot structure has now been decontaminated.

More than 99 percent of the plutonium that was in the building before the fire has been retrieved. Eventually the AEC expects to reuse essentially all of this plutonium. The balance is combined with other fire debris and will be handled routinely as is other radioactive waste material.

Reported Nuclear Detonations, January 1970

(Includes seismic signals from foreign test areas)

The U.S. Atomic Energy Commission announced that it had conducted two nuclear tests during January 1970.

Both nuclear tests were of low yield (less than 20 kilotons TNT equivalent) and were conducted underground, January 23 and January 30, 1970, by the Atomic Energy Commission at its Nevada Test Site.

On January 29, 1970, the United States recorded seismic signals which originated in the Soviet nuclear test area in the Semipalatinsk region. The signals were equivalent to those of an underground nuclear explosion in the low-intermediate yield range (20–200 kilotons TNT equivalent).

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

STRONTIUM-90 AND CESIUM-137 IN TOTAL DIET SAMPLES—A COMPARATIVE STUDY OF DATA: *P. D. Roecklein, C. E. Smedley, and R. E. Simpson. Radiological Health Data and Reports, Vol. 11, February 1970,* pp. 47–64.

Six federal, State, and private organizations have published values for strontium-90 and cesium-137 activities in total diet samples for the period, January 1961 through December 1967. The data reported by these organizations have been statistically compared to determine how well the values of the several agencies agree. Our results show that there is agreement (at a significance level ( ) equal to 0.05) in about 60 percent of the cases for comparable samples collected at about the same location and time and analyzed by similar methods. The 40 percent disagreement may be due to differences in samples, however, the specific sampling sites within a geographical area cannot be verified.

Keywords: Cesium-137, diet, strontium-90.

ORDER BLANK FOR RHD&R

To: Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

Please enter my subscription for Radiological Health Data and Reports. I am enclosing Money Order ☐ Check☐ for this subscription. ($6.00 a year; $1.50 additional for foreign mailing.)

Please address RHD&R as follows. ______________________________

____

____

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C., 1969
For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Subscription price $6.00 a year, $1.50 additional for foreign mailing.
Price for a single copy of this issue is 50 cents.

February 1970

GUIDE FOR AUTHORS

The editorial staff invites reports and technical notes containing information related to radiological health. Proposed reports and notes should contain data and interpretations. All accepted manuscripts are subject to copy editing with approval of the author. The author is responsible for all statements made in his work.

Manuscripts are received with the understanding that other identical manuscripts are not under simultaneous consideration nor have appeared in any other publication.

The mission of *Radiological Health Data and Reports* is stated on the title page. It is suggested that authors read it for orientation of subject matter.

Submission of manuscripts

Send original and one legible copy of the paper, typed double-spaced on 8½ by 11-inch white bond with 1-inch margins.

Submitted manuscripts should be sent to Managing Editor, Radiological Health Data and Reports, Bureau of Radiological Health, PHS, Rockville, Md. 20852.

Preparation of manuscripts

The Government Printing Office style manual is used as a general guide in the preparation of all copy for *Radiological Health Data and Reports*. In addition, *Radiological Health Data and Reports* has developed a "Guide" regarding manuscript preparation which is available upon request. However, for most instances, past issues of *Radiological Health Data and Reports* would serve as a suitable guide in preparing manuscripts.

Titles, authors: Titles should be concise and informative enough to facilitate indexing. Names of authors should appear on the third line below the manuscript title. Affiliation of each author should be given by a brief footnote including titles, professional connections at the time of writing, present affiliation if different, and present address.

Abstracts: Manuscripts should include a 100- to 150-word abstract which is a factual (not descriptive) summary of the work. It should clearly and concisely state the purpose of the investigation, methods, results and conclusions. Findings that can be stated clearly and simply should be given rather than to state that results were obtained.

A list of suggested keywords (descriptors) which are appropriate indexing terms should be given following the abstract.

Introductory paragraph: The purpose of the investigation should be stated as early as possible in the introductory paragraph.

Methods: For analytical, statistical, and theoretical methods that have appeared in published literature a general description with references to sources is sufficient. New methods should be described clearly and concisely with emphasis on new features. Both old and new methods, materials, and equipment, should be described clearly enough so that limitations of measurements and calculations will be clear to the readers. Errors associated with analytical measurements and related calculations should be given either as general estimates in the text or for specific data in appropriate tables or graphs whenever possible.

Illustrations: Glossy photographic prints or original illustrations suitable for reproduction which help enhance the understanding of the text should be included with the manuscript. Graphic materials should be of sufficient size so that lettering will be legible after reduction to printed page size (8½ by 6½ inches).

All illustrations should be numbered and each legend should be typed double-spaced on a separate sheet of paper. Legends should be brief and understandable without reference to text. The following information should be typed on a gummed label or adhesive strip and affixed to the back of each illustration: figure number, legend, and title of manuscript or name of senior author.

Tables: Tables should be self-explanatory and should supplement, not duplicate, the text. Each table should be typed on a separate sheet, double-spaced. All tables must be numbered consecutively beginning with 1, and each must have a title.

Equations: All equations must be typewritten, preferably containing symbols which are defined immediately below the equation. The definition of symbols should include the units of each term. Special symbols, such as Greek letters, may be printed carefully in the proper size, and exponents and subscripts should be clearly positioned. Mathematical notations should be simple, avoiding when feasible such complexities as fractions with fractions, subscripts with subscripts, etc.

Symbols and units: The use of internationally accepted units of measurements is preferred. A brief list of symbols and units commonly used in *Radiological Health Data and Reports* is given on the inside front cover of every issue and examples of most other matters of preferred usage may be found by examining recent issues. Isotope mass numbers are placed at the upper left of elements in long series or formulas, *e.g.*, ^{137}Cs; however, elements are spelled out in text and tables, with isotopes of the elements having a hyphen between element name and mass number; *e.g.*, strontium-90.

References: References should be typed on a separate sheet of paper.

Personal communications and unpublished data should not be included in the list of references. The following minimum data for each reference should be typed double-spaced: names of all authors in caps, complete title of article cited, name of journal abbreviated according to *Index Medicus*, volume number, first and last page numbers, month or week of issue, and year of publication. They should be arranged according to the order in which they are cited in the text, and not alphabetically. All references must be numbered consecutively.

Reprints

Contributors are ordinarily provided with 50 courtesy copies of the articles in the form of reprints. In cases of multiple authorship, additional copies will be provided for coauthors upon request.

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
WASHINGTON, D.C. 20201

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF H.E.W.

If you do not desire to continue receiving this publication, please CHECK HERE ☐; tear off this label and return it to the above address. Your name will then be promptly removed from the appropriate mailing list.